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THE UNIVERSITY IN THE MODERN WORLD

THE full report of the proceedings of the 1949 Conference of the Universities of Great Britain and Northern Ireland (*Nature*, **165**, 104 ; 1950) has just been published. At that Conference, Sir Walter Moberly's book "The Crisis in the University" was discussed, and it is interesting to find from a recent book by Dr. R. S. K. Seeley* that Sir Walter Moberly's views are reflected to a considerable extent in Canada. There is, further, a remarkable similarity of thought between these Hazen Lectures and the general trend that found expression in a series of talks on "The Idea of a University" broadcast by the B.B.C. in the Third Programme during March and April. The article on "Research, Reality and Religion" contributed by the Very Rev. H. A. Jones, Provost of Leicester, to the *Universities Quarterly* for May should help further to remove misunderstandings as to the meaning of Sir Walter's remarks about religion and the universities apparent in the rambling discussion at the Home Universities Conference, which led Sir Walter to protest rather feelingly.

Mr. Jones gives it as his opinion that while the investigation of the physical universe with no consideration of metaphysical or theological questions, on the assumption that ultimate reality is unknowable, has liberated enormously the energies of scientific men, the effects on the work of the universities as a whole are sufficiently dangerous to warrant the warnings in Sir Walter Moberly's book. In the first place, the growth of technological studies has tended to produce an attitude of mind which is the exact opposite to the attitude of the man of science as described by Thomas Huxley in his famous letter to Charles Kingsley. While the scientific man engaged in research is already in the psychological and spiritual attitude which makes worship possible, the technician (as such) must undergo a psychological revolution before worship is other than somewhat unreal. Linked with this greater tendency to treat spiritual reality as unknowable or non-existent, there is the conception of education as primarily a process of acquiring knowledge ; and with the increasing demands on the teaching side of the universities in comparison with research, it is little to be wondered at that most students have little opportunity to acquire the truly scientific attitude of mind.

Even in science, Mr. Jones believes we can no longer escape from metaphysics. If the knowledge and insights derived from modern science are to be truly integrated with those derived from other aspects of human experience, we must overthrow or modify the metaphysics of Hume—or at least of Hume as mediated to us through Huxley. Knowledge of the deepest kind, knowledge which demands most of men and women, is not knowledge of things or of logical propositions, but knowledge of persons ; and Mr. Jones believes we shall not escape from our difficulties in education until we return to this. More than courses

* The Functions of the University. By the Rev. R. S. K. Seeley. Pp. ix + 79. (London, New York and Toronto : Oxford University Press, 1948.) 6s. net.

in the history and philosophy of science will be needed, and he lays his chief stress on the need for a renewed sense of the common fellowship of all those who are engaged in the tasks of teaching, research and scholarship. He believes it would be comparatively easy, even in a large university, to create a conviction that the many and various subjects of study and research are different aspects and expressions of one deep underlying spiritual reality. If scientific men can be included in the society which the collegiate system makes possible in the older universities, and which—as Michael Oakeshott stressed in the first of the talks on "The Idea of a University"—makes a university a place where the student has the opportunity of education in conversation with his teachers, his fellows and himself, religion and theology would take their rightful place in the life of the universities and make their contribution to the common fundamental attitude of mind which such a society tends to produce. Mr. Jones remarks that it is in reality itself and not in any one aspect of the human approach to it, or even in the sum of such human approaches, that the integration of human life can be found.

Mr. Oakeshott's view that the pursuit of learning in a university is essentially a conversation, depending on the stimulating contact of minds at all stages of development, particularly the contact of minds trained in different disciplines, found general support in the subsequent talks in the series, though other speakers, like Lord Lindsay of Birker, quickly pointed out that the university could not be so detached from the world or the preparation of men and women for the professions as Mr. Oakeshott suggested. A university has always had, as Sir Walter Moberly said, some sort of social purpose, both changing society and being changed by society. The real danger is that to which Mr. C. R. Morris, Prof. R. Pascal and Sir Walter all directed attention—that under the pressure of present conditions there will be no common body of knowledge, and the conversation postulated by Mr. Oakeshott will not take place.

None of the talks provided much guidance, however, as to how this is to be achieved. Prof. P. M. S. Blackett did not discuss this issue at all; indeed, his address illustrated Mr. Jones's contention that we commonly fail to distinguish between the scientific and the technician's frame of mind. In the concluding talk Sir Walter urged convincingly that the universities would fail to make their proper contribution to the modern world if they did not contribute to the solution of the problem of values as well as of technical problems. Much in the modern scientific temper is admirable and must be incorporated in the new tradition and framework. But, as Sir Walter put it, if the Christian scheme of things is true at all, it is relevant to university studies, and to recognize this is to give effect to Prof. Pascal's principle that the university should study man in the totality of his activity and his relations. To ignore this is to produce a distorted picture and to adopt a partisan attitude, not one of neutrality as between a secularist or a religious outlook.

It is here that Sir Walter is more convincing than his opponents. He does not believe in concealing unreality or glossing over differences or doubts, but has faith in the competence of the universities to train leaders for a changing society. He would have students helped to disentangle and examine critically their assumptions and emotional attitudes—the assumptions underlying the particular studies they pursue, the profession for which they are preparing, the judgments they are accustomed to make and the political or religious convictions they are accustomed to hold. He would also explore the basic values of the university so as to reach a greater clarity and agreement; and he sees clearly that there are some issues so fundamental that neutrality is impossible, and reiterates that we cannot without absurdity have an open mind about the value of having an open mind.

In this address, as in his reply to the discussion at the Home Universities' Conference, Sir Walter seemed to remove some of the misinterpretations of his book. A university cannot do its work without unfettered freedom of thought and utterance, relentless pertinacity in following the argument wherever it leads, punctilious accuracy in noting and recording evidence, a judicial temper in approaching controversial questions, a respect for opponents and a sustained effort to understand them. Beyond this, however, Sir Walter urges that the university may properly share in a few other assumptions basic in the community to which a university belongs, such as, in our Western world, an impregnable respect for the individual human person. Such assumptions affect educational policy and, in general, as he says rightly, we need a more penetrating analysis of such values and a greater measure of agreement than exists at present.

Such a re-examination and re-assessment of tradition cannot be made either without the universities contributing or without a re-examination of the Christian element in that tradition. The universities, as Sir Walter reminds us, are among the most obvious organs of the community for the discussion and sifting of ideas, and they cannot fully serve the community even in that way if they ignore or exclude the religious issue and take up an attitude which, as Sir Walter has done well to reiterate, is not one of neutrality but of opposition. It would be instructive to learn whether the discussion groups used in the Department of Electrical Engineering at the University of Birmingham, as recently described by Prof. A. Tustin, as well as Prof. L. J. Russell at the Home Universities' Conference, to stimulate the personal development of students and to broaden their interests, have confirmed the soundness of Sir Walter's judgment here.

That experiment of the last three years is, moreover, particularly interesting in view of the main points made by Dr. Seeley, whose Hazen Lectures, referred to earlier, were concerned especially with the student element in the university community and the place of religious values. It was also urged in a recent series of articles on scientific education in the *Times Educational Supplement* that a really well-thought-out course of doctrinal religion is an essential

part of the training of a scientific worker. What he wants to know and what he is entitled to know is what theories about the relations between men and men, the relation between man and the universe and the relation between man and God the Christian Church actually puts forward, and on what facts of experience these theories are based. It is of the greatest importance that he should see that there are real problems to be solved in this as well as in the material sphere, and that great thinkers are, and have been, active here as well as in science.

This is really part of the general informative course designed to give the academic man of science an overall view of the scientific picture of the universe and man. It is the complement of the specialist part of the education of the scientific worker in the academic field, which must endeavour principally to furnish him with an adequate weapon for further investigation, whether this takes the form of research or of general inquiries into daily problems. Methods and techniques are as important as acquiring a mass of information. When we consider that this should include teaching the man of science how to frame an experiment, carry it out accurately and assess and evaluate the information thus obtained, as well as to judge the degree of reliability of his results and where and how to find the material for checking his work by the work of others, it should be apparent that this part of the scientific side of his training is linked with exactly the type of discussion of assumptions and values which Sir Walter Moberly and Dr. Seeley are concerned to promote.

The value of an approach of this type is particularly apparent where there is a tendency, as Dr. Seeley suggests there is in Canada, for the general public to think of a university as a place of teaching rather than of learning, and to forget that the university is a community of men and women engaged in the common task of the pursuit of knowledge. That pursuit, as Dr. Seeley admits, must be selective; but it is not haphazard, and it is a profoundly spiritual one. A university does not discharge its responsibility to itself if it does not accept responsibility for guiding and directing its students as well as for teaching and research. One danger to-day is that university expansion has hindered the satisfactory discharge of the first of these tasks because the student body has grown and the teaching staff become too small. A second danger is the absence of clear thinking about the nature of the freedom to which the university student is entitled. There are limits to such individual freedom wherever a common end is sought, and Dr. Seeley regards it as one of the great weaknesses of the Canadian universities that students are rarely made aware of the nature of the community which they enter. At some point the student must be made aware of the discipline involved in an inquiry after truth, and in words that remind us of Sir Walter's book, Dr. Seeley remarks that it has yet to be established whether there is a place in our civilization for a university which is nothing more than a collection of free individuals with no common ground and has therefore no contribution to make to society at large.

Dr. Seeley reiterates this point after quoting Milton's definition of a complete and generous education—"that which fits a man to perform justly, skilfully and magnanimously all the offices both private and public of peace and war". The bearing of this on a university education lies in the adverbs which Milton uses, and the difficulty of attaining the ideals of a university with a minimum of staff is accentuated if the number of students is restricted now that students are increasingly entering the university from homes where books are a rarity and conversation seldom reaches an abstract level. That in itself encourages the tendency to think that the universities must turn out the finished product rather than men and women who are prepared for any occupation but fitted for no particular one.

Against this Dr. Seeley gives clear warning, and he firmly holds that a university should be jealous of its standards and produce graduates of only the highest excellence, as well as guarding against the temptation to multiply courses in order to satisfy outside interests. He believes that a university must be ready to abandon courses if they are no longer valuable or if better ones are devised. The main interest of his book, however, lies in what he says, after stressing the imperativeness of maintaining standards, about stimulating creative activity and about the universities recognizing their cultural responsibilities. If university students go out without an appreciation of cultural pursuits, without a knowledge of how to use leisure graciously and creatively, civilization will be poor indeed.

Here Dr. Seeley would go further than the experiment being tried at Birmingham, for while recognizing the value of group discussion, he urges that more discussion is also needed between teachers and students on the subject-matter of courses. Further, with Sir Walter and Prof. Russell, he recognizes that students should be given some indication of the principles upon which moral behaviour is to be founded, and that in practice we cannot be completely impartial. Obligation is laid upon those who believe in a moral purpose to teach as if they believe in it and to let the students know that there are those who believe in it. Neutrality here means the denial of moral purpose, and denying to students the knowledge that the existence of moral purpose is a live issue and that there are those who cannot find a meaning to life on any other terms. If our burning passion for truth is based upon a living belief in a moral purpose for society, we cannot communicate the passion without communicating with it the source from which it comes.

The whole spirit of inquiry is fundamental to university life, and for that reason Dr. Seeley believes that the university should offer a wide field for experiment in Christian thinking and living. He appears to be thinking in terms of Sir Walter Moberly's creative minority with a unique opportunity of demonstrating the Christian life and ethic unimpaired by denominational partialities. Like Sir Walter, he regards the university as responsible for seeing that the nature of a well-rounded life is made clear, and like him he recognizes that a university

cannot permit within its society elements which are self-destructive, which indulge in intellectual dishonesty or are subversive of everything for which universities stand. Freedom in the pursuit of truth is essential in a community of scholars; but it must be conditioned by the rights and purposes of the community as well as of the individual: if the two ever clash, those of the community must come first.

It is within those limits that Dr. Seeley claims that the protagonists of both the secularist and the religious point of view must be free to examine critically and explain their own assumptions and values, and to demonstrate their contribution to living a full life. That was Sir Walter's fundamental claim in "The Crisis of the University"; and unless it is admitted, the universities will be unable to exert their full influence against the pressure groups the existence of which in society is, in Dr. Seeley's view, one of the greatest threats to the freedom of the universities as well as to the values in national life, such as impartiality, integrity, moral courage and a sense of perspective. The plea is not for propaganda but for living—the provision of an antidote for fear, the confidence in which the passionate search for truth is conducted and the kindling of a spirit of adventurous life. The discharge of that function of a university safeguards a community of scholars from disintegrating into departmentalism, and inspires its members with both a concern for, and an understanding of, the values on which society depends.

A striking feature of all these discussions on the functions and the purpose of a university is the parallel they present with discussions on the preservation of political and industrial democracy. Here once again the solution of our problem lies largely in the creation of small groups in which the individual can find a real sense of partnership, and to which he or she can feel able to make some effective contribution. The universities have to establish such groups in which effective contact is possible between the junior and the senior members of the university community, and in which the discipline and tradition of a university are understood and freely accepted. In such groups and communities the critical re-examination of assumptions and values in which interpretation and fresh synthesis are possible can proceed; they can gain an appreciation of the best elements that make up the university or the Western tradition, whether drawn from the scientific or the ethical side, and even the junior members would be able to form their own judgment and make their decisions with an open mind and with the fearless and obstinate integrity which is a safeguard against the racketeer in whatever guise he appears. In such an atmosphere, not only would any attempt at propaganda be instantly detected and corrected, but also there should be no danger, such as that of which Prof. Pascal spoke, of professional ethics and loyalty building walls around itself and proving a rival to a wider social consciousness and ethics, because we have here a principle in harmony with the essence of scientific study.

CONSERVATION OF THE RESOURCES OF THE AMERICAS

Proceedings of the Inter-American Conference on Conservation of Renewable Natural Resources, Denver, Colorado, September 7–20, 1948

(Department of State, Publication 3382, International Organization and Conference Series 2, American Republics 4.) Pp. xi+782. (Washington, D.C.: Government Printing Office, 1949.) n.p.

THE United Nations Conference on the Conservation of Natural Resources, which met at Lake Success during August–September 1949, was preceded by an inter-American conference which covered approximately the same field, but excluding minerals. All the countries of the New World were represented, and the delegates and observers met at Denver, Colorado, during September 7–20, 1948, under the presidency of Charles F. Brannan (United States Secretary of Agriculture), with William Vogt as secretary-general. The programme included exhibitions and field trips, and Mr. Harry S. Truman was personally introduced at the closing plenary session.

The greater part of the day-to-day work was carried out in six parallel sections: 1, human populations and productive capacity of the land; 2, renewable resources and international relations; 3, land use and the social sciences; 4, dynamics of renewable resources; 5, education in conservation dynamics; and 6, making conservation effective. Altogether, some 111 papers were presented. A number of resolutions were passed urging the Pan-American Union, working in close relationship with the Food and Agriculture Organisation and with other agencies of the United Nations, United Nations Educational, Scientific and Cultural Organisation and other bodies, to take appropriate steps in the development and conservation of natural resources and especially in Nature protection and wild-life conservation.

On one day, September 18, the delegates were taken to an 850-acre western ranch four miles south-east of Denver, which was chosen as typical of 200 million acres of farm and ranch land, and there, before their eyes, it was remodelled by more than a hundred modern farm machines in a single day. Special attention was paid to soil erosion control in this area of 14 inches of annual rainfall. It is to be hoped that a report may be available later as to the progress of this farm.

Again and again in the discussions, emphasis was placed on the present lack of knowledge and the need for research; on the present rapid increase in populations; and the fact that "no population can long outrun its resources". It is perhaps surprising to find Kingsley Davis, director of the Division of Population, Columbia University, dogmatically asserting that "obviously both the United States and Canada are reaching the end of their period of rapid population growth . . . in the 1990–2000 decade, there will be no growth at all but a loss in population". On the other hand, Dudley Kirk, of the United States Department of State, says that "the United States and Canada will have to make way for an increase of 25 to 30 million more people by 1975". Many of the papers are valuable because they give brief summaries of the conditions in the countries concerned—such as Uruguay, Mexico, El Salvador and Colombia—and throughout the conference the emphasis is on soil erosion, "undoubtedly

encountered everywhere" in the Latin American countries, according to Manuel Elgueta, of Costa Rica, who urges that the "development of agriculture is bound to create more serious destruction of the land capital unless immediate study of land-use is carried out".

In view of the world-wide interest in under-developed areas and the implications of Mr. Truman's Fourth Point, this warning is salutary and timely—there is great danger that modern machines designed for mid-latitudes may cause untold harm in the little-understood tropics. L. DUDLEY STAMP

ON EXORCISING GHOSTS FROM MACHINES

The Concept of Mind

By Prof. Gilbert Ryle. Pp. 334. (London: Hutchinson's University Library, 1949.) 12*s.* 6*d.* net.

FOR thirty years the Logical Positivists have been rolling up their sleeves, spitting on their hands and boasting about the hard work they are just about to do with their marvellous new tool 'semantics'. A feature of the new tool is supposed to be a sort of super-language to correct the defects of ordinary language. Prof. Gilbert Ryle, in the meantime, has done some genuine work in correcting the defects of language, with no fuss, no jargon, no meta-languages: just plain English and common sense. He has also produced a very readable book, although it is rather too long and repetitive.

He takes up a traditional philosophical problem, the relation of mind and body, in order to show that a dualistic theory of the Cartesian type, the "myth of the ghost in the machine" as he puts it, leads to verbal confusions. Common speech and common sense in most cases avoid these confusions successfully, recognizing the distinction between persons and things, but treating persons in a unitary way—not splitting them up into a ghostly half and a mechanical half. Prof. Ryle's method may be described as empirical study at second-hand. Through the medium of ordinary linguistic usage which has survived the test of time, he appeals to common experience which each of us can confirm for himself by reflexion. This is the useful and legitimate kind of linguistic analysis and criticism; but it is at least as old as Socrates.

Prof. Ryle shows successfully that in use the theory of the ghost in the machine tends to turn into that of a little machine inside the big one, or a little man inside the big man, carrying out hidden operations inside a private theatre or peep-show. The thing becomes a tangle of false analogies and mixed metaphors. Prof. Ryle calls false analogies and mixed metaphors by the portentous title of "category mistakes", and incidentally falls into one himself in illustrating his use of the term (p. 16). He appears to assume that we can always use direct speech with literal meaning and always avoid metaphors and analogies. Yet his own language is often just as metaphorical and analogical as the language he condemns, though the metaphors and analogies are different. In trying to exorcise the ghost from the machine, he is in danger of emptying out the baby along with the bath water.

These dangers are clearly seen in the chapters on sensation and imagination. For example, he dismisses "images" in a very ingenious but high-handed way. When a person goes through the motions of looking or pretends to see, when there is nothing real to look at or to see, then, he says, the gap is the supposed "image". This conclusion (or prejudice) is that of one with very little mental imagery of his own who ignores all the evidence of special investigations of the past hundred years. What about the child with eidetic imagery who, when asked to draw an elephant, projects an image on the paper and runs his pencil round the outline? What about the person with a photographic memory who, when asked to quote something, can see the printed page and read off the required words?

Prof. Ryle deals in an equally high-handed fashion with the 'sense-datum' theory of perception, but never explains what he proposes to put in its place. Here, however, he is on stronger ground and his arguments deserve consideration. Yet here also he has no right to ignore all special studies of the subject, even in the sacred name of common sense. It is not far short of two centuries since Thomas Reid published his "Inquiry into the Human Mind", also an attempt to exorcise ghosts from machines and also in the name of common sense. Either ghosts are very stubborn or common sense is very feeble.

A. D. RITCHIE

INTRODUCTION TO THE SCIENCE OF VISION

Vision and the Eye

By Dr. M. H. Pirenne. (Frontiers of Science Series.) Pp. xx+187. (London: Chapman and Hall, Ltd., 1948.) 12*s.* 6*d.* net.

THE study of vision has now become so extensive and the literature on it so specialized that the student approaching the subject is often bewildered. Moreover, physicists, physiologists, psychologists and artists have all contributed to the welter of information. As a result, objective physical data on the properties of light, observations made during physiological experiments on animals and man, introspective analysis of subjective sensations and even practical observations on the mixing of pigments and on the effects of their juxtaposition may often be found inextricably entangled in many of the existing volumes of vision.

The author of this book is therefore to be congratulated on his objective and limited approach. He has wisely selected certain basic facts, which do not by any means cover the whole field; and he is mainly concerned with attempting a synthesis of how patterns of electromagnetic radiations, called light, falling on the eye are translated by the eye into such selective excitation of nerve fibres in the optic nerve as can eventually give rise to the perception of form, colour, distance and the like. The author is not concerned with the subjective aspects of vision, and, by eliminating these, he immediately clears the field of many of its more difficult entanglements and thus provides the student with a clear and logical approach to the subject.

While, however, the general approach is objective and logical, it is also somewhat conservative. There is also, perhaps, some lack of sympathy with the more biological aspects of vision, as, for example, in the discussion on the parts played by rods and cones and in the evolutionary aspects of the visual mechanism. Occasionally, also, the reader may feel that the

author is not entirely devoid of bias in the interpretation of observational results. For example, in Fig. 75 a single curve could be drawn through all the points with apparently as much accuracy as the two curves suggested on theoretical grounds. Again, on p. 156 it is stated that "there does not seem to be any evidence that entirely rod-free fields have different colour vision" from those containing rods, although previously, on p. 141, one finds that, when a field subtending 20′ in diameter falls on the middle of the fovea (which, on p. 27, is stated to be rod-free), then "the characteristics of colour vision correspond to a dichromatic system. All lights of the spectrum can be matched by suitable mixtures of blue light and red light." This apparent inconsistency is not, in fact, as glaring as it may seem at first sight, since there are other possible causes for the dichromacy of the foveal centre besides the absence of rods; but perhaps the point could, with advantage, have been made more explicit.

In spite of this, however, the book is well considered and clearly written, and forms an excellent introduction to the complex study of vision. The analysis of the minimum requirements of energy for the perception of light and of pattern, which incorporates much of the author's own investigation, is of particular interest.

E. N. Willmer

ENGLISH FARMING BOOKS IN THE EIGHTEENTH CENTURY

More Old English Farming Books

From Tull to the Board of Agriculture, 1731 to 1793. By G. E. Fussell. Pp. ix+186+8 plates. (London: Crosby Lockwood and Son, Ltd., 1950.) 15*s*. net.

SOME time ago Mr. G. E. Fussell published a volume on Old English farming books covering the period 1523–1730; he has now followed this up with a companion volume dealing with the period 1730–93. The dates can be fully justified: 1731 was the year in which Jethro Tull published his famous "New Horse Houghing Husbandry" which made the successful cultivation of turnips possible and so opened the way to the Norfolk rotation, the final break with the ancient three-field system. 1793 was the year of foundation of the first Board of Agriculture, which did so much towards the development of the craftsmanship that later raised English agriculture to the highest level in Europe.

The general reader would have been helped if Mr. Fussell had begun with an outline of the agricultural history of the period in relation to what had gone before and what came after; the author preferred, however, to start right away with an account of Jethro Tull and William Ellis. Of the two, Tull was by far the more interesting personality. An Oxford student who had to abandon his studies and political ambitions for health reasons, he had taken to farming but gave up for a time to travel in the south of France and in Italy, where he saw with admiration the methods of cultivating the vineyards; on his return he set out to adopt similar methods on his farm. His efforts are described in his book; the first edition is very rare, but William Cobbett's edition of 1829 is not difficult to find, and it is made more entertaining by Cobbett's own very racy comments. Tull has always aroused interest and admiration among agriculturists for his gallant struggle against adversity, due partly to a spendthrift son, and against sickness, working as he says "in pains of the stone and other diseases as incurable and almost as cruel".

Mr. Fussell's survey ends with Arthur Young, most famous of agricultural writers—"that wise and honest traveller" as John Morley called him—whose later years were terribly saddened by the death of his favourite daughter and by blindness.

In between Tull and Young came a crowd of much smaller people whom Mr. Fussell aptly calls the minor prophets, but who necessarily take up a considerable part of the book.

The period was agriculturally far more important for its practical achievements than for its writings. Bakewell, Townshend and Coke of Norfolk were all bringing about revolutionary changes in farming practice, but none of them wrote anything; indeed, it has been part of the irony of agricultural history that some of the best agricultural writers—Tusser, Young and others—have been very indifferent practitioners, whereas some of the best practical farmers have felt no urge to write. Some of the volumes had intriguing titles—"The Way to be Rich and Respectable", "Strictures on Agriculture", "Modern Eden; or the Gardener's Universal Guide"—but they lack the picturesqueness of some of the sixteenth- or seventeenth-century books and particularly the sonorousness of the Elizabethans, for none of the eighteenth-century publishers could approach the colophon of the 1578 Heresbach, "Imprinted at London for John Wight, dwelling in Paules Church-yarde, at the great North doore of Paules"; however, there is contained in some of them a good deal of shrewd common sense and information about agricultural practices which cannot easily be found elsewhere.

A few points might receive attention if another edition is called for. Tull's idea of tillage as a substitute for manure was developed by the Rev. S. Smith, of Lois Weedon, in the late 1840's and published by him in his pamphlets "A Word in Season" in 1849 and "Lois Weedon Husbandry" in 1856, and by 1858 the former had reached its sixteenth edition; copies of both pamphlets are in the Rothamsted Experimental Station along with other agricultural treasures. The method excited a good deal of attention, as labour was cheap and manure dear. It was tested at Rothamsted on Hoosfield during 1851–54 but found to be ineffective; the results were published in the *Journal of the Royal Agricultural Society* for 1856. Burnett's pamphlet, the only one mentioned by Mr. Fussell, was not published until 1859. The author gives the date of the first edition of William Ellis's "Modern Husbandman" as 1743; the Rothamsted copy is dated 1742, and includes only the months May–October. The Dublin edition of 1743 includes the whole year. The Rothamsted copy of the Dublin edition of Hales's "Compleat Body of Husbandry" (1757) is in four volumes, not two; the London edition of 1758–59 is also in four volumes. The London and Dublin editions differ in content and especially in arrangement. Mr. Fussell does not mention the "Continuation . . ." (1759), of which Rothamsted has a quarto edition. The second edition of Tull's "Horse Hoing Husbandry" is dated 1743, not 1740. It was the "Supplement to the Essay . . ." that reached a second edition in 1740; Rothamsted has no copy of the first, even if there ever was one.

The student of this period of agricultural history will find the volume useful; no other book deals with the subject so fully.

E. John Russell

TOBACCO MOSAIC VIRUS CRYSTALS AND THREE-DIMENSIONAL MICROSCOPIC VISION

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CRYSTALLINE inclusion bodies in tobacco plants infected by tobacco mosaic virus have been known since 1903[1], and circumstantial evidence has made it appear likely that these crystals are composed largely of the virus protein[2,3]. The present work makes it appear even more likely than before that the crystals are pure virus protein, and shows the crystals to be of considerable interest from several quite different but related points of view. On account of the exceptionally large dimension of the protein particle, it has been possible for the first time to make, in part at least, a structure analysis of the crystal using visible light in a manner analogous to that of X-ray diffraction. As a result, it has been possible to settle the controversial question[3] of the length of the rod-shaped virus particle in the living plant. Also, the interpretation of the appearance of the crystals, as seen with the microscope, leads to a theory of the formation of images of three-dimensional objects[4]. We also wish to report some new observations on the optical properties of purified virus protein.

Previous observations on the optics and crystallography of what we shall assume to be tobacco mosaic virus crystals (though we must stress that it has not yet been proved that the crystals consist of virus protein alone) have been somewhat restricted[3], partly due to the difficulty of making suitable microscopic observations on bodies which cannot be removed from the plant. We have confirmed the fact that the crystals in leaf-hair cells show hexagonal prism and base faces only and are positively birefringent[3]; and we have measured the birefringence, obtaining the thickness of the crystal by rolling over an isolated hair cell containing the crystal. The birefringence is 0·0046 and, if we assume the crystal to be composed of isotropic rod-shaped particles lying parallel to the hexagonal axis and use the birefringence value of wet virus gel, the water content of the crystal is one of two values, either about 30 or 60 per cent. We have made use of the Wiener formula of form birefringence[5], which is not accurate unless the water content approaches 100 per cent. An accurate theory of form birefringence for hexagonally packed rods is required and is being prepared[6]. The refractive index of the crystal relative to cytoplasm was measured directly by observing, with the Bertrand lens, the deviation of a pencil of light passing through two crystal faces inclined at 60°. The cytoplasm probably has a refractive index close to that of plant sap ($\sim 1{\cdot}344$) and this observation suggests a water content in the crystal of approximately 60 per cent. The interference figure in convergent light was observed after compensating the birefringence of the cell walls; the crystals were uniaxial or, at least, if biaxial, β was less than 20°. The ultra-violet absorption spectrum (ordinary ray) of the crystal has been measured using a reflecting microscope. As expected, this spectrum agrees well with that obtained with pure oriented virus gel when the electric vector of the light is perpendicular to the rod-length of the virus particle.

The most interesting feature of the crystals was discovered, however, when the crystals were seen to be crossed by regularly spaced light and dark bands when viewed near extinction with crossed nicols and a bright light source (Fig. 1). This meant that the crystals did not have precisely straight extinction, but were composed of flat layers about 3000–6000 A. thick lying parallel to the basal face of the crystal, and that, from one layer to the next, the optic axis was inclined alternately a few degrees on one side and then the other with respect to the hexagonal axis; in other words, the crystals were finely lamellar-twinned. Observation of bent crystals showed, as one would expect, that the light and dark bands interchanged as the crystal was turned through extinction. The bands had the same appearance when viewed in any direction normal to the hexagonal axis.

The width of each band was frequently about 3000 A. and never less, and it was very tempting to suggest that the ~ 2800 A. long virus protein rods observed in the electron microscope[7] compose the crystal, each layer in the crystal being built up of rods packed side by side and pointing in a direction slightly inclined to the normal to the plane of the layer; in other words, the width of the bands observed was equal to the length of the virus particle. Various models of the crystal composed of helical and zig-zag arrangements of straight rods have been considered, but none has yet been found which accounts for all the properties of the image and of the diffraction spectra described below. One difficulty is that the structure is not constant, the thickness of the layers tending to increase, apparently continuously, as the crystals grow. In early stages of infection (about one week), the crystals are thin hexagonal plates composed of only a few layers

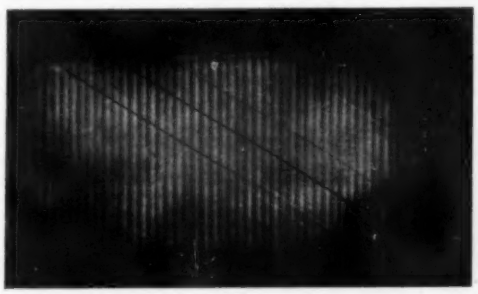


Fig. 1. Crystal of tobacco mosaic virus between crossed nicols. × 1,450

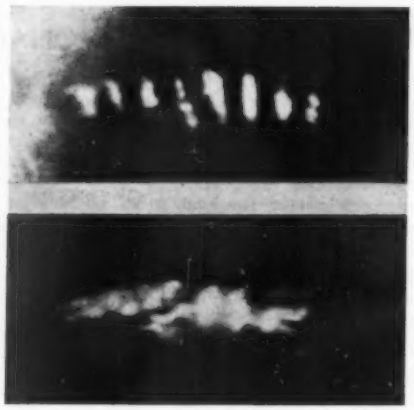


Fig. 2. Tobacco mosaic virus crystal showing helical edges, and bands between crossed nicols. × 2,650
(*a*) Near extinction position; (*b*) 45° from extinction position

(crystals of one or two layers only have been observed), and as the time of infection increases the crystals grow in the direction of the hexagonal axis, the number of layers increasing.

The presumably helical arrangement of the virus particles in the crystal causes the prism edges of the crystal to be themselves helical. In rare crystal fragments one sometimes finds that the pitch and angle of the helix have both become exceptionally large, and in these cases the helical contour of the crystal shows very clearly (Fig. 2). The bands which appear between crossed nicols show that the optic axis for any layer of the crystal is parallel to the edge of the crystal and to the length of the virus particle. In such a crystal the virus particles have probably aggregated end to end, and the pitch of the helix bears no special relation to the length of the unaggregated particle, 2800 A. Normally, however, it is clear that the particles are not aggregated, because the crystals show marked basal cleavage and the individual layers building up the crystal can sometimes be seen clearly in dissolving crystals jutting out sideways from the main body of the crystal (Fig. 3). On allowing a fragment of leaf to stand a few hours in distilled water, the crystals can be seen dissolving and reaggregating in a most entertaining fashion. We have seen (and photographed) paracrystalline needles similar to those observed by Beale[3], but crossed by bands; banded tactoids; crystals without external geometry but crossed by highly distorted bands; birefringent spherulites; banded laminæ; systems of small tactoids; and crystals containing spherical inclusions. It is clearly a characteristic of the virus to aggregate in a remarkably large number of ways.

The appearance of the bands in the normal crystals was surprising in one respect, that, although the crystal was often extended 10 or 20 μ in a direction normal to the plane on which the objective was focused, the contrast or 'visibility' of the bands was very high. Clearly those parts of the crystal out of focus were not contributing much out-of-focus light which would reduce the contrast of the image. The explanation of this phenomenon is surprisingly simple if one recognizes that any three-dimensional object in which there is a periodic variation, in one direction only, of any optical property such as scattering, absorption, birefringence or refractive index, will exhibit Bragg reflexion of light; and it is only as a result of the interference between the direct light beam and the Bragg reflected light that the periodic lamellar structure will be rendered visible. As the direct and reflected light waves may be considered as plane, the result of their interference is visible in the microscope as a system of equally spaced parallel dark and light bands. Bands of this type can also be seen in lamellar twinned crystals of potassium chlorate in which Bragg reflexion of visible light has previously been described[4].

Between crossed nicols the first- and second-order diffraction spectra from virus crystals can be observed using the Bertrand lens (Fig. 4), and the images showing the first and second harmonics of the band system may be observed if the crystal is illuminated at the required Bragg angle. The phenomena are identical with those for plane gratings as described by Abbe, except that diffraction is limited to angles of incidence corresponding to Bragg reflexion. Well-formed virus crystals used as crystal monochromators show separation of the 5460 and 5780 A. lines of the mercury spectrum.

It is interesting to note that if one has an object composed of equally spaced and roughly vertical laminæ alternately slightly stained and clear, the highest-contrast image is obtained not by passing light rays vertically through the whole depth of the laminæ, but by illuminating at the Bragg angles. An account of a theory of three-dimensional microscopic vision and resolving power will be given elsewhere[4], but one of the main conclusions is immediately apparent and may be stated as follows: the image of an object consisting of an extended periodic arrangement of vertical (or somewhat inclined) laminæ corresponds with a section of the object cut by the plane on which the microscope objective is focused, provided the numerical apertures of the objective and condenser are sufficient to pass light which will give the various orders of Bragg spectra corresponding to the Fourier components of the periodic arrangement. If the object is not periodic, and consists of one or two laminæ, the image again corresponds with that part of the object focused on. The out-of-focus portions of the object do not appear blurred but contribute to the image in focus; however, as the Bragg angles are no longer defined in a non-periodic object, it is not possible to illuminate at the Bragg angles only, and general illumination is superimposed on the image. This kind of approach enables one to interpret with certainty the appearance

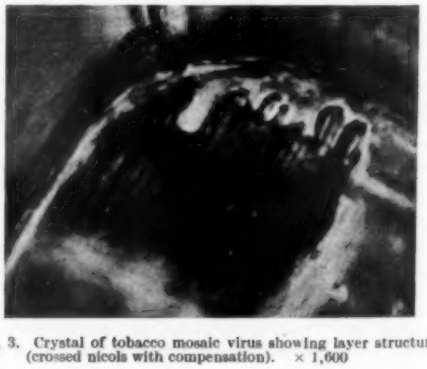
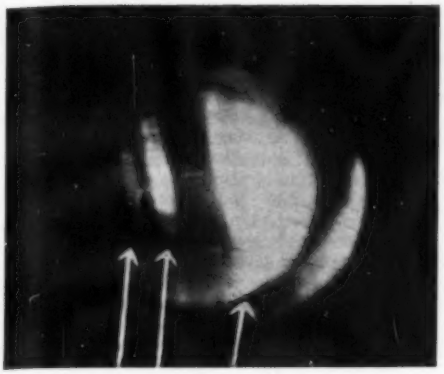


Fig. 3. Crystal of tobacco mosaic virus showing layer structure (crossed nicols with compensation). × 1,600



b *a* *c*

Fig. 4. Bragg spectra from tobacco mosaic virus crystal. (*a*) First order; (*b*) second order; (*c*) direct light

of many images in the microscope, such as those of edge-on views of birefringent sheets; for example, some sperm heads, lamellar structures in chromosomes, lamellar twinned minerals, etc.

Oster[9] has found that, in freshly prepared virus gel in which the 2800-A. rods have not aggregated end to end, it is sometimes possible to observe iridescent domains which exhibit Bragg reflexion of visible light, indicating the presence of sets of planes of varying refractive index spaced approximately 3400 A. apart. He suggested that the virus particles 2800 A. long are arranged in sheets, the length of the particles being normal to the plane of the sheet, and with water separating the sheets. The band and Bragg phenomena in the virus crystals in the plant, however, only showed between crossed nicols, and the structure of the crystals was clearly different from that suggested by Oster.

One of the main objects of this investigation—to establish the length of the virus particle in the living plant—could not be achieved with certainty by a study of the crystals with helical structure. The discovery in the plant of a second and much rarer type of crystal with properties similar to those observed by Oster *in vitro* was therefore of great interest. These crystals showed bands when viewed with unpolarized light incident from one side at the Bragg angle. In this way a picture of the crystal in phase-contrast illumination[10] showing periodic variation in refractive index of the crystal was obtained. The crystals were positively birefringent ($\sim 0{\cdot}005$) with straight extinction, and showed bands between crossed nicols. The spacing varied from 4000 A. to 3200 A., and it was clear that the structure must be of the general form suggested by Oster, with layers of virus particles separated by water. As these crystals have the same properties as those observed in purified material composed of 2800-A. long particles, it is reasonable to suggest that they are crystals of pure virus, and we can almost say it is proved that these crystals in the plant are composed of the 2800-A. rod particles. The fact that these crystals, and the crystals with helical structure, are built up of layers of virus particles has been confirmed by Mr. H. L. Nixon[11], of Rothamsted Experimental Station, who has obtained electron microscope photographs of virus in dried plant sap showing aggregation of 2800-A. rods side by side and with their ends in a straight line at right angles to the length of the rod.

Finally, we wish to report that repetition of birefringence measurements on pure aggregated salt-free virus gel, approximately 100 per cent oriented, gave a maximum value of 0·0054 for wet gel and approximately 0·0007 for dried gel. Previous values[12] were 0·006 and 0·003 respectively. It would appear likely that the low value for dry gel is to be accounted for by the idea that the virus particles pack without interspace when dry, and that the birefringence of the virus is all form birefringence. Repetition of the experiments of Butenandt *et al.*[13] on the ultra-violet dichroism of oriented virus solution shows that their absorption curves are approximately correct, except that the curves for electric vector perpendicular and parallel to virus particle length should be interchanged. We feel that interpretation, as made by Butenandt *et al.*, of dichroism data of this kind is not justified and cannot tell us how the tryptophane and nucleic acid groups are arranged in the virus particle. The general difference between the heights of the two absorption curves for different directions of electric vector is likely to be due to form dichroism[14] resulting from the difference of refractive index of the virus particle and water. Also it is by no means certain, as has been suggested, that the tryptophane absorption peak at about 2900 A. occurs when the electric vector is parallel to the plane of the indole ring. Further study of this question is required.

We wish to acknowledge the very generous provision of plants and virus by Dr. R. Markham; helpful suggestions from many workers in this field, in particular Prof. J. D. Bernal; and the continual encouragement and advice of Prof. J. T. Randall. We are also very grateful to Dr. A. K. Wells, of the Geology Department, King's College, London, for the loan of the polarizing microscope used throughout this work.

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COLOUR SYSTEMS AND ATLASES

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Colour Group of the Physical Society

THE word 'system' is in general use in our language; so almost any paint-manufacturer's catalogue could be said to be related to a system. For the purpose of this article, however, it is used in a more restricted sense, and, in this restricted sense, a colour system is not necessarily associated with a collection of colour specimens—an atlas—although it often is. An atlas apparently unrelated to a system merits attention only when it is outstanding. For example, an atlas based on the mixture of colorants in stated proportions is, if comprehensive, useful to practitioners in applied colour. One of this sort containing 1,248 samples was produced by G. Plochere in California in 1948. An

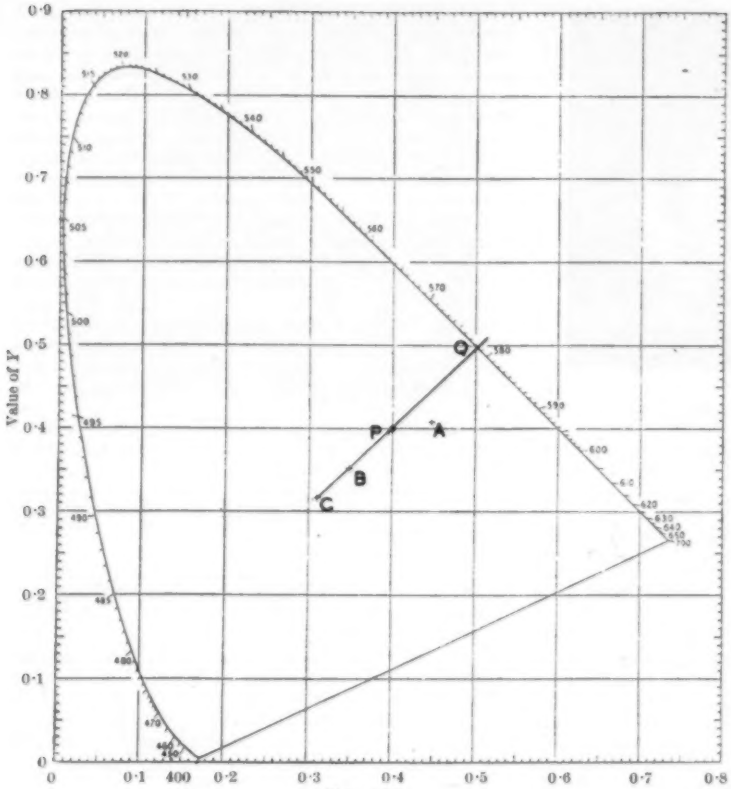


Fig. 1. C.I.E. chromaticity chart. P is the point representing colour specified by $x = 0{\cdot}40$, $y = 0{\cdot}40$. A, B, C are 'white' points corresponding to illuminants A, B, C. CP divided by CQ fixes the purity. The wave-length at Q fixes the dominant wave-length of colour P if illuminant C is used

atlas that takes into account the textures of surfaces is also outstanding; several have been produced by the British Colour Council, the newest scheme of which will eventually have a systematic numerical notation. Systematization of verbal descriptions to make a colour dictionary is another useful activity. Maerz and Paul produced their "Dictionary of Color" in New York in 1930, with 7,056 samples and a comprehensive comparative account of terms used in books and atlases. All these are useful; but, broadly speaking, an atlas unrelated to a system based on principles that can be discussed in visual terms is of restricted usefulness, and has no general significance for people interested in the science of colour.

It is in the devising of a system that the difficulties inherent in colour science appear. Any colour, whether from a primary or secondary source[1], is finally judged by a human observer. So, to the objective and subjective conditions that affect an observer, there must be added the subjective variables into which he can analyse his judgment of colour quality. These variables cannot be eliminated, but under controlled conditions they can be, so to speak, standardized, and then the most subjective possible specification of colour quality can be made.

The C.I.E. system (I.C.I. in U.S.A.), agreed at meetings of the Commission Internationale de l'Éclairage from 1931 onwards[2], is an objective specification of colour matches. It is based on the matching of spectral colours by varying quantities of three monochromatic stimuli. Three hypothetical stimuli, not realizable in practice, can be calculated in such a way that a colour can be specified in terms of three tristimulus values, X, Y, Z, that express the ways in which radiant energy from an equal-energy source are distributed in contributing to the total colour stimulus received by a standard observer. Since any other colour is composed of a mixture of spectral colours, the integrated values of X, Y and Z specify the colour, provided the distribution of illuminant is also specified. The value of Y is arranged to give the luminance factor of the surface directly. The three chromaticity co-ordinates, x, y, z, are the ratios of X, Y, Z to their sum and therefore always add up to unity. Only two are therefore independent and they can be plotted on a two-dimensional diagram. When the axes of this diagram are arranged so that x is measured along the abscissæ and y along the ordinates, the result is the usual chromaticity chart (Fig. 1). Consequently the only variables needed are Y and two of x, y and z (usually x and y). These, with the stated illuminant, specify the colour. This specification is abstract and mathematical. It is accepted internationally and acts as a master reference-system. But it is without meaning for the inexperienced and can be used only by scientifically trained personnel. It gives little indication of the appearance of a colour. For example, it is not easy to see from the specification $x = 0{\cdot}40$, $y = 0{\cdot}40$, $Y = 0{\cdot}5$, illuminant C, that what is specified is a sort of pastel yellow when viewed in ordinary diffuse daylight.

A C.I.E. specification as ordinarily given bears no relation to subjective variables realized in the judgment of colour quality. The chromaticity chart, however, can be utilized to give a closer relationship to these variables. On the chart the spectrum locus is drawn (charts for regular use always have the spectrum locus shown and numbered), that is, a line joining points representing the chromaticity co-ordinates of all the spectral monochromatic radiations, the most saturated colours obtainable. If P is the point representing the colour specified above, a straight line drawn from the illuminant point C (that is, the 'white' point) to P, and continued, will cut the spectrum locus in a point Q. In this example the wave-length of Q is 5,784 angstrom units, and this is the *dominant wave-length* of the colour P. The

proportion of CP to CQ specifies the *excitation purity* of the colour P, that is, a figure expressing where P stands between white light C and the saturated colour Q. So the derived specification of the colour is now in terms of dominant wave-length, purity and luminance factor. (These can also be derived directly from colorimetric matching by mixing white light with a monochromatic radiation.)

Anyone of normal colour vision, if confronted with a set of coloured patches, at once recognizes differences that he expresses as 'hue'—"a is red and b is blue". In addition, he can make a series consisting of patches of the same hue and changing only in *lightness*. Further, he can make another series of patches of the same hue and lightness but differing in a quality—"a is a greener green than b"—that is usually called *saturation*, an estimate of the proportion of colourfulness. However, it is not always precisely this quality that is estimated, but something else needing another name for an estimate of difference in degree of chromatic colour from achromatic colour (grey). If enough patches are available, he can make either of his series in steps of just noticeable difference. Even if enough patches are not available, he can still estimate equality of difference between successive steps. If he makes one series of a certain lightness and hue but differing in equal steps of colourfulness, and then tries to make another series of the same hue but much lower lightness and still differing in steps of colourfulness equal to the ones he made in the first series, he finds that the number of steps between achromatic colour and fully saturated colour is less; whereas if the estimates were in steps of saturation, a proportion, a greater number of steps should have been possible, because very saturated colours generally tend to be darker. This distinction between saturation and some other quality of colourfulness is a fine one and is unnecessary if comparisons are confined to series of the same lightness, when saturation and colourfulness are equivalent in subjective estimation.

The subjective variables hue, saturation and lightness correspond with the objective variables dominant wave-length, purity and luminance factor. But the correlation is not unity. For example, a series of constant dominant wave-length and luminance factor but differing purity is not necessarily interpreted as one of constant hue.

In the judgment of a surface colour, other subjective variables than the ones given above can be used. The Ostwald system employs four, consisting of hue, whiteness, blackness and colourfulness, and the paint-mixer uses variables related to these. The dyer has subjective estimates corresponding to the amount of dye that is needed and to whether the dye used is bright or dull. To some extent his variables can be correlated with those used by the paint-mixer, a subject discussed in the "Report on Colour Terminology" issued by the Physical Society.

The facts that correlation between subjective variables and C.I.E., or colorimetric, objective variables is not unity, that the plain C.I.E. specification is not immediately recognizable in terms of colour appearance, and that subjective variables vary among different users, make an atlas of specimens necessary for rapid and accurate work in all spheres where colour is used. Such an atlas should be stable and comprehensive, with a simple notation, related as nearly as possible to subjective variables, and related to a systematization. The notation used then gives a quasi-objective specification of a colour, a specification that is negotiable between users of the same system.

Two systems, and their atlases, have become widely known. One was devised by A. H. Munsell (1858–1918), a Boston (Mass.) art teacher, in 1905. The other was devised by the eminent German physical chemist F. W. Ostwald (1853–1932) in 1917. Their most recent atlases are the "Munsell Book of Color" and the "Color Harmony Manual" respectively, both produced in the United States in 1942. The former contains 960 specimens and the latter 943. C.I.E. analyses of the mat specimens of both atlases have been made by American physicists[3]. Recently (1947) Villalobos has produced his "Atlas de los Colores" in Argentina. It contains 7,279 specimens and is too recent for adequate appraisal here, though the great number of samples and their relation to a system based on three variables make it apparently worth serious consideration.

The Munsell system is a colour-appearance one. He systematized on the basis of three subjective variables, namely, hue, value, chroma. Value corresponds to lightness, chroma to the colourfulness mentioned above. Colour can never be specified with less than three variables, and so the custom has grown of referring to the spatial systematic arrangement of colours as a colour-solid. The Munsell solid is built from a central vertical trunk consisting of equal steps of achromatic colour from black at the bottom to white at the top. The subjectively equal steps of chroma go out horizontally like branches from the trunk. The different hues are distributed round the circumference of a circle in a horizontal plane. Thus a vertical mid-section consists of two parts, one on each side of the vertical axis. Each consists of a plane of constant hue but value increasing upwards and chroma increasing outwards to an irregular boundary depending on the value and

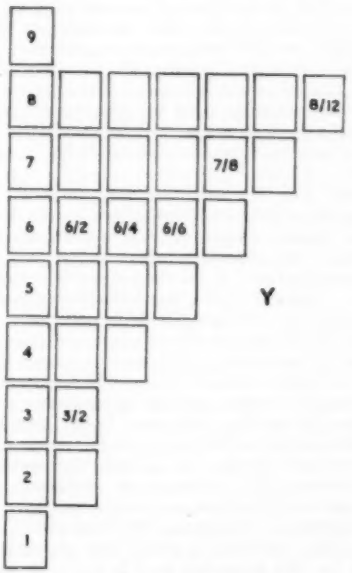


Fig. 2. Half a vertical mid-section through the Munsell colour solid. Figures up the left-hand represent values of achromatic series. Figures in other rectangles specify value and chroma. The hue is Y (yellow)

hue (Fig. 2). A horizontal section consists of colours of the same value varying outwards from the centre in chroma and around the centre in hue. His notation expresses hue, value, chroma, in that order. The stages of chroma can be extended as pigments of greater saturation become available.

The Ostwald system is often called a 'colour-mixture' one because the samples were originally determined by an objective mixture of colours. One variable is, of course, dominant wave-length, though Ostwald called it hue. The remaining colour quality is specified in terms of three variables corresponding to the objective variables of pure-colour content (that is, content of most saturated chromatic colour), black content and white content; for Ostwald, in revolt against the physicists' preoccupation with monochromatic spectral light, analysed surface colours, related to others as they usually are, into the four subjective variables of hue, pure-colour quality, blackness and whiteness. Mixing was done originally on a rotating disk, and if the black, white and pure-colour sectors are considered as fractions of the whole disk, then the total for any resulting colour must always be unity, giving an equation fundamental to the rationale of the Ostwald system: $w+b+c=1$. This has enabled Ostwald and his successors to utilize an equilateral triangle to display quantitatively the mixtures of w, b and c (dominant wave-length being constant for any one triangle), thus giving symmetry to the colour-solid. Ostwald then used the Fechner law connecting stimulus and sensation. He increased his objective mixture of colour sector of dominant wave-length with white (or black) by quantities the logarithms of which made equal increments. In this way, he argued, he bridged the objective–subjective gap according to scientific law. To make his colour-solid he arranged his pure colours (without black or white content) on the circumference of a circle in such a way that he could embrace the mystique of complementary hues being diametrically opposed. To every hue there belongs a vertical plane that is an equilateral triangle with an apex at the pure-colour part of the circumference and the black-to-white base vertically through the centre of the circle. Thus the whole solid becomes a symmetrical double cone. Ostwald numbered his hues and gave letters to the black and white properties. The notation then became a number followed by two letters (Fig. 3).

Neither the Munsell nor the Ostwald atlas is perfect, quite apart from whether the basic systematics is sound. Loci of Munsell constant-chroma specimens, for example, when drawn on a C.I.E. chromaticity chart, show sudden sharp irregularities. These are clearly errors, for whatever the shapes of loci might be, they ought to be smooth. Earlier Ostwald plottings showed even worse jumps. It is possible to estimate the correct mixtures for either system from smoothed curves. This has been done for Munsell colours[4], giving re-notations to be distinguished from the published book notations, and this offers the possibility of another atlas with more evenly graded steps. By postulating spectrophotometric curves of a certain type, physicists can state 'ideal' colours of maximum saturation and estimate the theoretical boundaries of sections of a colour solid. The Ostwald system has one outstanding defect, for the equation $w+b+c=1$ settles the pure colour as the existing pigment of greatest saturation; so as new pigments of greater saturation become available, the whole system, if it is to remain generally useful, has to be re-made to retain symmetry, equality of steps, and notation.

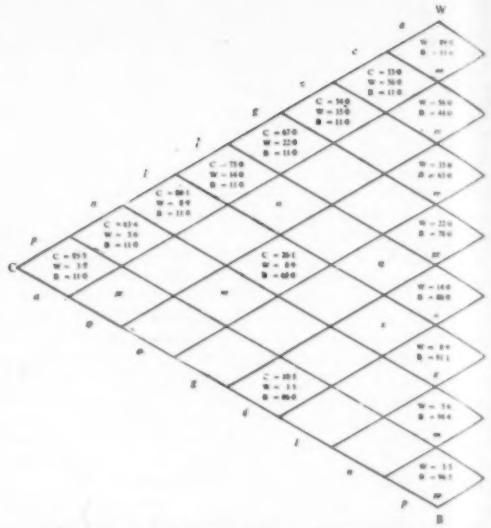


Fig. 3. Half a vertical mid-section through an Ostwald colour solid. It is an equilateral triangle. The proportions of white content, black content, pure-colour content for several positions are shown. The method of specifying the position in the triangle in the Ostwald notation is also shown in some positions. The vertical base on the right is the scale of achromatic colours increasing in lightness upwards

So much interest has been shown by professional men, industrialists and scientific men in this subject of colour systems and atlases, especially at a course on colour lighting organised at the Royal Institute of British Architects by the Council of Industrial Design and the British Colour Council, that the Colour Group of the Physical Society recently arranged a general discussion for its fiftieth meeting. The secretary, R. G. Horner, gave a general paper surveying the whole field, and much of the factual material of this article came from his paper. At the meeting, R. F. Wilson gave an account of his own atlases produced by the British Colour Council and already widely accepted in Great Britain, but it is not at all clear what the principles of his system are. It was notable that several non-academic speakers gave from personal experience their appreciation of the Munsell system, and appealed for the adoption of a standard system to eliminate the present confusion. Accordingly, the executive committee of the Colour Group of the Physical Society appointed on April 26 a sub-committee "to review the present situation regarding systems of colour description, to investigate the desirability of adopting a standard system, and to recommend any action that should be taken".

[1] Terms used are defined in the Report on Colour Terminology (London: Physical Society, 1948).

[2] An account of the arguments leading to the C.I.E. system is given in Wright, W. D., "The Measurement of Colour" (Adam Hilger, Ltd., 1944).

[3] Kelly, K. L., Gibson, K. C., and Nickerson, D., "Tristimulus Specifications of the Munsell 'Book of Color' from Spectrophotometric Measurements", *J. Opt. Soc. Amer.*, **33**, 355; *Nat. Bur. Stand. J. Res.* (RP 1549), **31**, 55 (1943). Granville, W. C., Nickerson, D., and Foss, C. E., "Trichromatic Specifications for Intermediate and Special Colors of the Munsell System", *J. Opt. Soc. Amer.*, **33**, 376 (1943). Foss, C. E., Nickerson, D., and Granville, W. C., "Analysis of the Ostwald Color System", *J. Opt. Soc. Amer.*, **34**, 361 (1944).

[4] Newhall, S. M., Nickerson, D., and Judd, D. B., Final Report of the O.S.A. Subcommittee on the Spacing of the Munsell Colors. *J. Opt. Soc. Amer.*, **33**, 285 (1943).

THE CHEMICAL RESEARCH LABORATORY, TEDDINGTON

FOR the fourth year in succession, the Chemical Research Laboratory of the Department of Scientific and Industrial Research held a series of 'open days' during June 27–30. The guests included staff from government departments, universities, industrial firms and the technical Press. In view of the large numbers attending in previous years an extra session was announced, and in this session places were reserved for industrial firms who had not previously received invitations. The response to this announcement indicated clearly that this opportunity to view the work in progress is welcomed by the scientific community.

The research staff of the Laboratory work within six main divisions, namely, the Corrosion of Metals Group, the Inorganic Chemistry Group, the Radiochemistry Group, the Organic Chemistry Group, the High Polymers and Plastics Section and the Microbiology Section. Formerly, microbiological investigations at the Laboratory were concentrated on the study of underground corrosion by the influence of sulphate-reducing bacteria; but, as will be shown later, the scope of the work has been considerably widened, and in January last an independent Microbiology Section was constituted. During the open days the work of these Groups and Sections was set out in great detail; but this note is confined to a brief statement of the nature of the work with special reference to the newer exhibits.

The Corrosion of Metals Group has a large programme concerning the corrosion of metals and its prevention in immersed and atmospheric conditions; in addition, investigations on soil corrosion continue in collaboration with the Microbiology Section. An electron diffraction apparatus has been installed and is being used for the examination of surface films stripped from metals by the iodine–methyl alcohol technique. Marked changes in the mechanism of film formation in the neighbourhood of 200° C. have been indicated in the course of a study of the oxide film on iron. Other films, such as those on nickel, aluminium and phosphated steel, have been removed and examined by the above technique.

Exhibits of special practical interest were those illustrating the use of sodium benzoate in conjunction with a smaller proportion of sodium nitrite as an inhibitor of corrosion, the use of which is particularly advantageous in that both cast iron and soldered surfaces are protected, a result that has hitherto been difficult to obtain when these metals have been present together in the same system. Glycol anti-freeze solutions, with and without the inhibiting chemicals, taken from new car radiators after running for some 2,500 miles were in striking contrast; the solution with the inhibitor was water-clear, whereas the other contained much suspended corrosion product. Work in collaboration with the British Rubber Producers' Research Association has revealed that the mixed inhibitor can be incorporated in rubber latex, and metal assemblies protected by rubber films with and without benzoate and nitrite showed clearly the benefit of the new inhibitor. A simplified atmospheric corrosion test has been devised with a view to its adoption by other laboratories; a prototype apparatus was seen in use.

In collaboration with the British Shipbuilding Research Association, a new research has been commenced on the corrosion of boiler tubes with particular reference to Scotch marine boilers; four experimental boilers have been installed.

In previous years the Inorganic Group has displayed specimens of gallium and germanium metals obtained from flue dust, and in view of the interest in these metals samples have been sent on loan to various laboratories for studies of their special properties. The physical properties of gallium are being investigated in collaboration with the National Physical Laboratory, and a newer exhibit showed the remarkable anisotropy of this metal in regard to electrical and thermal conductivity. A new investigation is the treatment of phosphate rock by methods to reduce the consumption of sulphuric acid. A non-hygroscopic product made by the action of a mixture of nitric and sulphuric acids was on view, together with examples of 'complete' fertilizers, that is, containing the three essential plant foods, phosphorus, nitrogen and potassium. Trials of these products as fertilizers are being undertaken, and other methods of converting rock phosphate are being studied. A grating spectrograph is now in operation to supplement the prism spectrographs for the analysis of metallic ores. A well-equipped microanalytical laboratory, which is part of this Group, now provides an analytical service for the Laboratory.

The greater part of the work of the Radiochemistry Group is carried out on behalf of the Division of Atomic Energy of the Ministry of Supply, and is concerned with the analysis and treatment of radioactive ores. Typical methods of treatment were exhibited, together with physical methods of analysis, including colorimetry, polarography and the measurement of fluorescence.

An exhibit of special interest was the further development in chromatographic methods for the separation and estimation of metals and acid radicals by the paper strip and cellulose column. During the year the separation of a number of groups of elements has been studied, including niobium and tantalum and the platinum metals and gold. A new automatic fraction collector has been designed and constructed in the Laboratory; this collects exact volumes of liquid independent of variations in flow-rate, drop-size or specific gravity of the liquid, and without contamination by traces from the preceding sample.

Methods for measurement of radioactivity include apparatus for active carbon (C^{14}), which is now used on a routine basis. The method depends on the counting of active carbon in carbon dioxide gas.

The Organic Group is concerned with the purification of organic compounds and the precise determination of their physical constants, the utilization of tar constituents and the preparation of organic intermediates containing labelled atoms (C^{13}). A precision freezing-point apparatus which has been developed at the Laboratory and uses a pulsating gas pressure to mix the liquid was exhibited.

A new exhibit was a low-temperature still for the preparation of pure hydrocarbons for use in the calibration of mass spectrometers; this was wholly constructed in the Laboratory and is fitted with automatic methods of control. Large-scale glass apparatus is being used on an increasing scale for unit operations, and examples were on view of a continuous solvent still, a reflux unit and a sulphonation apparatus.

An exhibit of considerable interest to organic chemists was a set of molecular models designed and constructed in the Laboratory. They approximate to

the Stuart pattern and are machined from cast phenolic resin (see *Nature*, July 8, p. 59).

A newly erected spinning-band fractionating column is being used for the purification of fatty acids.

The main effort of the High Polymers and Plastics Section is being devoted to a study of the ion-exchange properties of high polymers, in particular the effect of polymer structure on ion-exchange equilibria and kinetics. An interesting exhibit was a 'mixed-bed' deionization column. This apparatus, which consists simply of a mixture of a strongly basic resin with a strongly acidic resin in a glass column, provides a very convenient method of preparing water of very low conductivity (specific conductivity = $0{\cdot}1 \times 10^{-6}$ mhos).

The Microbiology Section exhibited work on the growth requirements of sulphate-reducing bacteria, showing the progressive increase of growth obtained in a series of media ranging from purely inorganic (autotrophic growth) to a very rich organic media. The importance of certain amino-acids for growth was illustrated. Other exhibits showed the quantitative reduction of sulphate to sulphide by these organisms and the competitive inhibition of the reduction by selenates. Work on the functions of sulphate reducers in the underground corrosion of metals was shown, with examples of corroded water and gas mains and suggested methods of prevention. Examples of the photosynthetic green and purple bacteria, which oxidize hydrogen sulphide to elementary sulphur, and of sulphur-oxidizing bacteria, were shown. Included in this Section is the newly formed National Collection of Industrial Bacteria, which maintains more than three hundred strains. Since January 1, 1950, the Collection has sent out some one hundred and fifty cultures in response to requests not only from research laboratories in Great Britain but also from Belgium, Ceylon, Czechoslovakia, Finland, France, Germany, Holland, India, Italy, Poland, Sweden and Trinidad. Methods of preservation, diagnostic tests and classification of bacteria were illustrated.

In addition to the research groups and sections, reference should also be made to the well-equipped workshops, where much of the special experimental plant is designed and constructed. An interesting exhibit on the machines were the jigs used in the preparation of the molecular models.

OBITUARIES

Dr. J. S. Gooden

JOHN STANLEY GOODEN was born in Adelaide on April 11, 1920. His early education was at the Pultney Grammar School and later Saint Peter's College. He was at the University of Adelaide during 1938–41, where he concentrated on physics and mathematics, graduating in 1941 with first-class honours in physics. He was also proficient in sport, being a valued member of the lacrosse and cricket teams, and a good lightweight boxer.

Early in 1942 he joined the Australian military forces, working on radar problems. In that year he married Miss Claire Ward, daughter of the headmaster of Prince Alfred College, Adelaide. In 1943 he was invalided out of the army after applying for active service, and joined the Radio Physics Laboratories of the Australian Council for Scientific and Industrial Research in Sydney, where he became noted for exceptional experimental ability and his wide knowledge of physics. After the end of the War he worked on the production of one-million volt electrons from cavities excited by pulsed magnetrons, and was the first to attain success in this field.

In December 1945 Gooden arrived in England, and led the team under Prof. M. L. E. Oliphant in the construction of the 1,000 million-volt proton synchrotron in the Nuffield Laboratory at the University of Birmingham. He was responsible on this project for the major part of the general and detailed design and theoretical work, and his ability and energy were an inspiration to all members of the group. It is very sad that he has not lived to see the completion of this large and difficult project after putting into it more than four years of very hard work.

Dr. Gooden made considerable contributions to the theory of particle accelerators, in particular to that region where the motion cannot be regarded as either classical or extremely relativistic. For this work he was awarded the degree of Ph.D. of the University of Birmingham. He also developed the technique of paramagnetic nuclear resonance for the accurate measurement of rapidly rising magnetic fields, as in the proton synchrotron. This led him to investigate this effect under non-adiabatic conditions. During 1947 Dr. Gooden made an extensive tour of many physics laboratories in the United States of America.

Dr. Gooden was a member of the council of the Atomic Scientists' Association. His chief hobby was painting, and his outside interests included the history of art, music and social conditions. The friendship and hospitality of both him and his wife were highly valued by his colleagues.

In early May of this year, Dr. Gooden and his wife and young son flew back to Adelaide, where he fought hard to regain his health; but he died on June 9.

W. I. B. SMITH

Dr. J. G. F. Druce

IN the early hours of June 22, Gerald Druce died in a London hospital after six months of failing health and much pain. Born in 1894 at Leamington Spa, Druce was educated at Kendrick School and University College, Reading, and at University College, London, taking his M.Sc. in 1921. It was at University College that he first met Héyrovský, through whom he became interested in Czechoslovakia and its people. In 1920 he paid the first of more than thirty visits to that country, and in 1923 was awarded the degree of Doctoris Rerum Naturalium of the Charles University, Prague—a distinction shared by few Englishmen.

During most of his professional life, Druce was chemistry and botany master at Battersea Grammar School, and at the time of his death was head of the Chemistry Department. It was, in fact, in the temporary laboratory in the playground of the School at its original site on St. John's Hill, Clapham Junction, that Druce carried out his early work in search of the missing elements 43, 75 and 93, congeners of manganese, and in 1925 he published, with F. H. Loring, one of the three almost simultaneous papers announcing the discovery of 75 (rhenium). His pupils of those days will well remember the excitement of his isolation of a few colourless crystals of potassium perrhenate from pyrolusite. Yet Druce was an unassuming man; he knew his subject well and knew how to pass on his knowledge to others.

His practical classes were a model and his technique impeccable. The untidy laboratory and slapdash experimenting were anathema to him. Among his scientific writings were the monographs: "Brief Outline of the History of Science" (1925) and "Rhenium" (1948).

To mention his scientific work alone would be to tell only half the story, for Druce was a man of letters as well as a man of science, a scholar and a traveller. During the past thirty years he and his wife, and later their son, visited most of the countries of Europe, and he became fluent in many languages, including Czech and the Slavonic tongues. He once remarked that he learned his languages the 'easy' way, by living with the people. Yet, of the countries on the Continent, Czechoslovakia was his first love, and his writings on that country and its people revealed the depth of his understanding of their problems; in 1937 he was invested with the Order of the White Lion for his cultural and scientific work. He was also an honorary foreign member of the Masaryk Academy of Work and a corresponding member of the Royal Bohemian Scientific Society. In 1943 he was awarded the London M.A. degree for a thesis on "The Role of Men of Science in the Czech National Revival Movement".

His passing is mourned here and abroad, and those of us who received from him our first introduction to chemistry may indeed count ourselves fortunate.

KENNETH PANKHURST

Dr. H. Wambacher

ON April 25 Dr. H. Wambacher died in Vienna at the age of forty-eight after a long illness. Dr. Wambacher is mainly known for her work relating to scientific uses of photography, and especially for developing the method of detecting tracks in photographic emulsions of corpuscular rays due to atomic disintegrations and cosmic radiation. She worked at first together with Dr. M. Blau (now of New York). Her work is distinguished by the detection of the first multiple atomic disintegration ('star') in the emulsion of an Ilford plate, which was exposed for some months on the Hafelekar near Innsbruck (Tyrol). This discovery was followed by several publications concerning the occurrence of 'stars', their dependence on the number of tracks, the altitude, etc. The results of this work were not only of the greatest interest to scientific workers in this field, but also were of value to manufacturers producing special plates for nuclear research.

Dr. Wambacher's work was acknowledged by the award by the Vienna Academy of Sciences of the Jgnaz Lieben Prize for physics, 1938 (together with Dr. Blau).

G. ORTNER

NEWS and VIEWS

Prof. Egon Orowan, F.R.S.

THE Massachusetts Institute of Technology has recently announced that Dr. Egon Orowan has been appointed to a full professorship on the staff of its Mechanical Engineering Department. He will be taking up his new duties in October 1950. Dr. Orowan was born in Budapest in 1902, and studied at the Technical University of Berlin-Charlottenburg, where he continued for some years as a teacher and carried out research with Prof. Becker. On his return to Hungary he was for some time in charge of the krypton gas works of the United Incandescent Lamp and Electric Co. Eventually Dr. Orowan left Hungary, and in 1937 he resumed research on the mechanical properties of metals in the Physics Department of the University of Birmingham. In 1939 he went to the Cavendish Laboratory, where his researches were at first supported by the British Iron and Steel Federation and later by the Nuffield Foundation. He was given the title of reader by the University of Cambridge, and has had a group of about a dozen research students working under him for a number of years.

Dr. Orowan is well known in Great Britain for his work in metal physics. He combines an active and inquiring mind with an outstanding ability to design and construct ingenious apparatus. He has worked upon the deformation of single crystals, the theory of rolling, plasticity at high rates of deformation, the yield point of steel, and many other problems. He has been a member of many committees, and has taken part in numerous scientific gatherings, where his lively mind always stimulated the discussions. He has received a number of honours while in Great Britain, among them the Thomas Hawksley Gold Medal of the Institution of Mechanical Engineers in 1945 and the fellowship of the Royal Society in 1947.

Royal Naval Scientific Service: Mr. W. R. J. Cook

MR. W. R. J. COOK has been appointed chief of the Royal Naval Scientific Service in succession to Sir Frederick Brundrett, now deputy scientific adviser to the Ministry of Defence (see *Nature*, July 1, p. 17). Mr. Cook, who is forty-five years of age, was educated at Trowbridge High School and the University of Bristol, where he obtained the B.Sc. degree with first-class honours in applied mathematics in 1925. He followed this with two years fundamental research in theoretical physics at the same University, obtaining the M.Sc. degree in 1927 before taking up an appointment under the War Office in the Research Department at Woolwich. During 1927–35 he was engaged on research work in field of gunnery ballistics, the determination of shell velocities in flight and of pressures, temperatures and rates of heat transfer in guns. From 1935 he worked on gas dynamics and rocket development, and in 1939 was transferred to the Ministry of Supply Projectile Development Establishment. In 1940 he was appointed to the Ministry of Supply headquarters as an assistant director in the Directorate of Projectile Development, and was responsible for the assessment and planning of rocket requirements and research. In 1943 Mr. Cook returned to the Projectile Development Establishment as superintendent (R. and D.) in technical charge of all research and development; but in 1945 he was again recalled to the Ministry of Supply headquarters as deputy director of the Directorate of Guided Projectiles. He became chief superintendent of the G.P. Establishment at Westcott in 1946. In 1947 he transferred from the Ministry of Supply to Admiralty service as the director of physical research in the Royal Naval Scientific Service. In this post he has shown outstanding ability and great energy, gaining a very high reputation with both Naval and scientific staff in a comparatively short period.

Aeronautical Engineering at Southampton: Mr. E. J. Richards

THE appointment of Mr. E. J. Richards to the newly established chair of aeronautical engineering in University College, Southampton, marks a development of unusual interest. He goes to a department which has already achieved good simple material equipment for teaching and investigation. It has been devised and made with the simplicity which is a necessary consequence of the small funds which have been available. An example of this development is the 6 in. × 2½ in. supersonic air tunnel, using as its driving fluid steam from a boiler which was available. The cost and time of construction of the unit was, therefore, much smaller than would have been involved in the conventional plan of using compressed air as the driving fluid. The tunnel works satisfactorily, and gives a Mach Number of 1·4 for periods of one minute at intervals of six minutes.

Prof. Richards was educated at University College, Aberystwyth, and later at St. John's College, Cambridge. After some two years research work on aircraft structures with the Bristol Aeroplane Co., he transferred to the National Physical Laboratory in 1939. From 1945 until the present time Prof. Richards has been with Messrs. Vickers-Armstrongs at Weybridge, first as chief aerodynamicist and later as assistant chief designer. He has served on several of the committees of the Aeronautical Research Council and has made special visits to the United States to study the development of wind tunnels and other experimental technique. He has this year been awarded the George Taylor Gold Medal of the Royal Aeronautical Society for the best paper of the year. Prof. Richards's wide knowledge of aeronautical science and his experience of applying it to practical design form an excellent foundation upon which future aeronautical engineering education at Southampton will be based. His experience of the personal qualities which are desirable in engineers to be employed on research and technical development of aircraft will also give great advantage to his future college work.

Veterinary Science at Brisbane: Prof. T. K. Ewer

DR. T. K. EWER has been appointed to the chair of animal husbandry in the Veterinary Faculty of the University of Queensland and will arrive in Brisbane in August. Dr. Ewer graduated in veterinary science from the University of Sydney in 1938. After graduation he spent nine years in New Zealand teaching and doing experimental work in animal husbandry at Lincoln Agricultural College, Christchurch. During the past two and a half years he has been investigating the metabolism of phosphorus and vitamin D in sheep in the Department of Animal Pathology, Cambridge, for which work he was awarded the degree of Ph.D. in 1949.

The Veterinary Faculty of the University of Queensland was first established in 1936; but teaching ceased in 1942. In 1946 teaching was resumed for the three preclinical years, and Prof. Ewer's appointment is the first move to re-establish the full five-year course. This chair is of special significance in being the first in animal husbandry in Australia, and its creation suggests the main direction in which the Queensland Veterinary School may be expected to develop. It is of interest to note that veterinary schools in South America are said to have recently re-organised their courses to give greater emphasis to animal production than to medicine. The requirements of the livestock industries in South America and Queensland obviously have much in common, so it is not surprising to see the same trends in veterinary education developing independently in these widely separated countries.

University of Nottingham: First Congregation

ON July 11, the University of Nottingham held its first congregation for the conferment of degrees. At the beginning of an impressive ceremony the chancellor, Lord Trent, delivered an address to the graduands. After pointing out the significance of the occasion, he went on to discuss the need and the opportunities for university graduates to engage in business, not only on the scientific and technical branches, but also on the administrative side. There were no honorary degrees, but a few official degrees were conferred, including that of M.A. upon Prof. Janko Lavrin, head of the department of Slavonic languages, for his books on Russian literature, and that of M.Sc. on Mrs. Nora McDermott, of the Faculty of Agriculture, for her work on potato trials. Of the 260 other degrees, the most noteworthy was the award of a D.Sc. to Dr. F. L. Rose, a former student of the University (then University College) and now of Imperial Chemical Industries, Ltd., who was the leader of the research team which, during the War, produced 'Paludrine', the well-known anti-malarial drug.

The Tensor Club of Great Britain

THE Tensor Club of Great Britain has been formed with the intention of putting engineers interested in tensor analysis into touch with one another, and, at the invitation of the organisers, Gabriel Kron has become patron. The Club has the following four specific objects that later may be extended: to enable each member to keep his fellow members informed of any work he is doing or proposing to do of interest to the Club; to ensure that the attention of all members is directed to any publication of interest to the Club that comes to the notice of any one of them; to provide a channel for the exchange of ideas and information, and to give individual help and advice when requested; and to promote the extended and increasing use of the techniques developed by matrix and tensor methods. The Club's activities—in the early stages, at least—will necessarily be confined to furthering its objects by correspondence. Membership is open to all those who are actively interested in determinants, dyadics, matrices or tensors, and their application to engineering, wherever they may reside. There is no entrance fee; members pay an annual subscription of one guinea, and associate members half a guinea. Prospective members and others who are interested should write to either of the Club's organisers, S. Austen Stigant, 7 Courtlands Avenue, Hayes, Kent, and W. J. Gibbs, 53 Hillmorton Road, Rugby.

Impact

UNESCO has just issued the first of a new bulletin of abstracts concerned with the international and social implications of science. The bulletin, *Impact*, will be published quarterly. The first issue contains an introductory statement on how science impinges on society and a bibliography giving details of the more important publications in English which have already appeared. Future issues will contain abstracts from the publications of other countries dealing with the effects of science on society. The first issue also

contains the report of an address by Dr. P. Brandt-Rehberg at the University of Copenhagen on "Science and Society", the report of an address by Dr. S. Tovborg-Jenson on world food problems, an address by Mr. Edmund W. Sinnott to the American Association for the Advancement of Science on the study of science by the amateur as well as one on the "Encouragement of Science" by Dr. J. R. Oppenheimer. *Impact* may be obtained from the Natural Science Department, Unesco, 19 Kleber Avenue, Paris 16, price 2*s*. 6*d*.

Industrial Fluorosis

MEMORANDUM No. 22 of the Medical Research Council, entitled "Industrial Fluorosis" (pp. 131 + 13 plates; London: H.M. Stationery Office, 1949; 4*s*. net), is a report made by the Fluorosis Committee of the Council. Its contents cannot be summarized in detail here; but it records a study of possible effects upon man and animals of the large amounts of fluorine liberated from a factory near Fort William, Scotland, engaged in the manufacture of aluminium by an electrolytic process. Part 1 of the report discusses the contamination by fluorine compounds of the area studied; Part 2 the effects of fluorine compounds on animals in this area; Part 3 the clinical, radiological, hæmatological and biological studies of human beings; Part 4 the dental condition of adults and school children in the area; and Part 5 the physical properties of bone in fluorosis. Appendixes, which summarize the literature on the toxicity of fluorine compounds and describe the analytical methods used, and the bibliography extending to more than four pages of small type, add to the value of this comprehensive study.

Wounds of the Extremities during the War

THE *British Journal of Surgery* is publishing, in four supplements, a permanent record of the achievements of British surgeons during the Second World War. "War Surgery Supplement No. 1" appeared in 1947 and dealt with "Wounds of the Head" (see *Nature*, **161**, 635; 1948). No. 2, edited by H. J. Seddon (pp. 261–347; Bristol: John Wright and Sons, 1949. 12*s*. 6*d*.) bears the sub-title "Wounds of the Extremities", and it maintains the very high standard of the preceding supplement. An outstanding feature of these supplements is the excellence of the photographic and coloured illustrations; and the text, although it is addressed mainly to surgeons, will also interest others. Supplement No. 2 deals with war injuries of the extremities in the forward areas of battle, missile wounds involving bone, the early treatment of penetrating wounds of joints, and war injuries of peripheral nerves and arteries. The methods used and the remarkably successful results obtained by modern surgery will interest anatomists and physiologists as well as surgeons. The other two supplements, which will deal with abdomino-thoracic wounds and plastic surgery respectively, should prove equally interesting. It is good to know that the skill of the surgeon is being recorded permanently in this remarkable series of publications.

New Methods of Glasshouse Fumigation

THREE modern methods of pest control by fumigation are reviewed by Mr. G. Fox Wilson in a recent short paper (*J. Roy. Hort. Soc.*, **74**, Pt. 10; 1949). Insecticidal smokes, produced by igniting pyrotechnic mixtures containing DDT, 'Gammexane' or 'Azobenzene', provide a very convenient method, but are apt to damage plant foliage near the generator. The amount of insecticide which condenses upon the leaves is not, moreover, by any means standard. Production of aerosols by atomization under pressure is also convenient, and probably less toxic to foliage. The use of continuous-flow aerosols, however, provides a very promising and practical method. The insecticide is here evaporated slowly and continuously by electric heat. Mr. Fox Wilson describes the result of trials with such an apparatus at Wisley. Perhaps the outstanding effect was a speedy and effective control, with continuous-flow aerosol DDT, of the greenhouse white fly. Adults of this species died within twenty-four hours, and, though the eggs and nymphal stages were unaffected, the adults were destroyed soon after they were produced. Success was also obtained against mealybug, and, in part, against aphids (which are not generally controlled by DDT), and soft scale. Negative results were recorded against eucalyptus sucker and the carnation tortrix moth.

Summer School in Mathematics at St. Andrews

A MATHEMATICAL summer school was held at St. Andrews during June 30–July 8, under the auspices of a group of mathematicians from the four Scottish Universities. It was attended by about forty university teachers and research students. After an opening lecture by Prof. H. W. Turnbull, on "Algebra and Algebraists", courses of lectures were delivered on "Group Representations", by Dr. D. E. Rutherford, of St. Andrews, on "Linear Associative Algebras", by Dr. W. Ledermann, of Manchester, and on "Topology", by Mr. A. G. Vosper, of Dundee.

1851 Exhibition Scholarships

THE Royal Commission for the Exhibition of 1851 announces the award of Overseas Science Research Scholarships for 1950 to the following: *Canada:* W. L. Davison (Dalhousie University, Halifax, Nova Scotia), for research in geology in the University of Edinburgh; N. R. F. Steenberg (Queen's University, Kingston, Ontario), for research in nuclear physics in the University of Oxford; R. M. Stow (University of Saskatchewan), for research in physical chemistry in the University of Cambridge. *Australia:* F. A. L. Anet (University of Sydney), for research in organic chemistry in the University of Oxford; P. J. Fensham (University of Melbourne), for research in physical chemistry in the University of Bristol; L. M. Jackman (University of Adelaide), for research in organic chemistry in University College, London; P. M. Nossal (University of Adelaide), for research in biochemistry in the University of Sheffield. *New Zealand:* L. S. Wolfe (University of New Zealand), for research in animal physiology and biochemistry in the University of Cambridge. *India:* R. C. Sahney (University of the East Punjab and National Physical Laboratory, Delhi), for research in physical chemistry in the University of Cambridge. *Pakistan:* R. Ahmad (University of the Punjab), for research in chemistry in the University of Cambridge or London. *Republic of Ireland:* S. R. Duff (University of Dublin), for research in organic chemistry in the University of Oxford.

Leverhulme Research Fellowships, 1950

AWARDS for research, tenable for periods up to two years, have been made by the Leverhulme Trustees to the following, among others, for work

indicated in brackets: *Fellowships:* Dr. J. M. Lambert, lecturer in botany, Westfield College, University of London (ecological investigations into the vegetation in the region of the Norfolk Broads); Mr. D. B. Scott, lecturer in mathematics, King's College, University of London (applications of modern abstract algebra to algebraic geometry); Prof. A. J. B. Wace, professor of classics and archæology, Farouk I University, Alexandria (Mycenæ and the civilization of the Ægean Bronze Age). *Research Grants:* Dr. C. W. Dixon, lecturer and chief assistant, Department of Preventive Medicine and Public Health, University of Leeds (epidemiology of smallpox and control of variola minor); Dr. V. Elwin, of the Tribal Art Research Unit, India (tribal art in east-central India); B. H. Farmer, St. John's College, Cambridge (pioneer settlement in Ceylon); E. Green, general secretary, Workers' Education Association (present-day apathy to adult education); Dr. J. H. G. Lebon, lately professor of geography, University of Ceylon (origins and development of rural settlement in Scotland); Dr. H. M. Muir-Wood, a principal scientific officer, Department of Geology, British Museum (Natural History) (morphology and classification of Brachiopoda); Dr. D. M. Steven, lecturer in zoology, University of Edinburgh (species relationships of British voles); Mr. J. Walton, education officer, Basutoland (native housing in Southern Rhodesia); Mr. J. W. Wright, inspector of surveys, Sudan Government (hydrology of the Riber Sobat and its relation with the White Nile). Information relating to Leverhulme awards can be obtained from the Secretary, Leverhulme Research Fellowships, 7 Bedford Row, London, W.C.1.

International Physiological Congress

THE Eighteenth International Physiological Congress will be held at Copenhagen during August 15–18. A large part of the programme has been reserved for 'general discussions', which will deal with selected physiological problems. These include: salt and water excretion; thermodynamics of muscle, hormonal control of fat metabolism; transport of substances across cell membranes; physiology of the retina, principles of spinal cord activity; and cardiac output in man. As on previous occasions, it has been necessary to arrange the scientific meetings in several sections which will proceed simultaneously. The Congress is to be followed by a meeting of the Scandinavian Pharmacological Society on August 19, at which the properties of adrenaline, *nor*-adrenaline and related substances will be discussed.

Announcements

SIR JOHN ANDERSON has been elected president for the coming year of the British Standards Institution in succession to Sir William Larke.

THE University of Manchester has conferred the honorary degree of M.Sc. on Dr. W. H. Brindley for industrial and public services. Dr. Brindley, who is librarian of Hardman and Holden, Ltd., Manchester, has been honorary secretary and treasurer of the Manchester Section of the Society of Chemical Industry since 1934, and honorary librarian of the Manchester Literary and Philosophical Society since 1940.

A JAPANESE National Institute of Genetics has recently been established at Misima under the directorship of Dr. Kan Oguma. At present it comprises three departments: (1) Phenogenetic; (2) Cytogenetic; (3) Physiogenetic. It is hoped to cover all branches of genetics, pure and applied, dealing with human, animal and plant material.

THE Second Biennial Congress of the International Union of Leather Chemists' Societies will be held in London during September 10–13, 1951, at Regent Street Polytechnic (Portland Hall Annexe), Great Portland Street, London, W.1, at the invitation of the Society of Leather Trades' Chemists. Further details will be announced in due course.

THE Electronics Section of the Scientific Instrument Manufacturers' Association is holding its annual exhibition and symposium at the Examination Hall, Queen Square, London, W.C.1, during September 5–8. As in previous years, a series of technical papers will be read by specialist scientific workers and engineers. Also, there will be a comprehensive display of the latest types of British scientific and electronic instruments. Entrance to the symposium itself will be by ticket of admission (covering also the exhibition), obtainable on application to the Secretary of the Scientific Instrument Manufacturers' Association, 17 Princes Gate, London, S.W.7.

THE Commonwealth Scientific and Industrial Research Organisation has decided to publish a new journal, *Australian Journal of Marine and Freshwater Research*, as a medium for the publication of research papers on the results of original investigations on sea, estuarine, and freshwater fisheries and cognate subjects. It will not appear regularly, but as material becomes available. However, it is expected that two issues of the *Journal* will be published each year; each issue will cost 7*s*. 6*d*. per copy. Correspondence should be addressed to the Secretary, Commonwealth Scientific and Industrial Research Organisation, 314 Albert Street, East Melbourne, C.2.

DR. F. S. STEWART, assistant and lecturer in bacteriology in Trinity College (University of Dublin), has been appointed to the chair of bacteriology and preventive medicine in the College, in succession to Prof. J. W. Bigger, who retires at the end of September. Dr. Stewart, who is thirty-five, was educated at Wesley College and at Trinity College, Dublin. He distinguished himself first in philosophy, turning later to medical studies. He has published papers on *Rh* immunization and on the antigenic modification of red cells by periodate.

THE McCharles Prize of 1,000 dollars, which is awarded periodically by the Canadian Institute of Mining and Metallurgy "for the discovery or improved development of new life-saving devices in the power and light industry, or for any notable achievement in scientific research in any useful practical line", has recently been presented to Christian Lapointe, of the Radioactivity Division, Mines Branch, Ottawa. The award, together with a medal, has been made to Dr. Lapointe in recognition of his researches on the measurement, concentration and extraction of uranium from its ores. Notable among the inventions originating from these researches is the Lapointe picker, an ore-picking belt controlled by Geiger counters, by means of which high-grade pitchblende concentrates are automatically prepared from the uranium ores mined at Great Bear Lake.

ERRATUM. In *Nature* of July 1, p. 17, column 2, paragraph 2, for "International Council of Biological Unions" read "International Council of Scientific Unions".

ISOELECTRONIC REACTIONS IN CONJUGATED SYSTEMS

By Dr. H. C. LONGUET-HIGGINS
Department of Chemistry, University of Manchester

Introduction

ALTHOUGH open to various theoretical objections, molecular orbital theory provides the only practicable method of calculating resonance energies and electron distributions in large molecules. Even so, in order to apply the theory to a large molecule, it has hitherto been necessary to solve sets of simultaneous linear equations; and this process is too lengthy to be undertaken by many organic chemists.

We shall here describe a new and very simple way in which molecular orbital theory can be used for the calculation of differences in unsaturation energy (that is, the energy of the π-electrons) between isoelectronic molecules, and differences in activation energy between isoelectronic reactions. (The word isoelectronic, here and later, is to be understood to refer to the π-electrons only; in this sense pyridine is isoelectronic with benzene.) This new technique avoids the necessity of setting up any secular equations, and can be applied without difficulty to very large systems.

Differences in Unsaturation Energy

Every conjugated organic molecule is isoelectronic with some hydrocarbon molecule or ion, real or hypothetical. Thus glyoxal is isoelectronic with butadiene, and aniline and phenol are isoelectronic with the benzyl anion. Let us denote by E the unsaturation energy of any given heteromolecule, and by E^0 that of the isoelectronic hydrocarbon. Then it can be shown by first-order perturbation theory that

$$E - E^0 \simeq \sum_r \alpha_r q_r^0, \qquad (1)$$

where α_r is an energy parameter associated with position r in the heteromolecule, and q_r^0 is the π-charge at the corresponding position in the isoelectronic hydrocarbon. The sum is taken over all conjugated atoms in the heteromolecule. The parameter α_r is usually assumed to depend only on the atomic number of atom r and its nearest neighbours; it is correlated with the difference in ionization potential between atom r and unsaturated carbon. Equation 1 is valid only if (i) α_r is small at all positions r, and (ii) corresponding bonds in the heteromolecule and the parent hydrocarbon have equal resonance integrals. These conditions are fulfilled in molecules containing only C, H and N; and in halogen compounds conjugation involving the halogen p-electrons may be neglected, to a good approximation. However, for organic molecules containing oxygen atoms, equation 1 is unfortunately rather a poor approximation.

Calculation of π-Charges

In order to obtain absolute values of $E-E^0$ from equation 1 it is necessary to know the parameters α_r and the π-charges q_r^0. The former are always the greatest single source of uncertainty in molecular orbital calculations; but if it is only required to know relative values of $E-E^0$ in isomers, this is not a severe limitation, because the charges q_r^0 can usually be found without difficulty.

The most important systems for which q_r^0 can be simply calculated are alternant hydrocarbons (that is, hydrocarbons with no odd-membered unsaturated rings) of the following types:

(1) Molecules or radicals, in which the number of π-electrons equals the number of conjugated carbon orbitals;

(2) Carbonium ions in which the number of π-electrons is even, the number of conjugated orbitals being one greater; and

(3) Carbanions, in which the number of π-electrons is even, the conjugated orbitals being one fewer.

Coulson and Rushbrooke[1] showed that in hydrocarbons of class (1) the π-charges are unity at every position; that is

$$q_r^0 = 1. \qquad (2)$$

Now an ion of class (2) is derived from a radical of class (1) by taking away the odd electron; and an ion of class (3) is obtained from a radical of class (1) by putting another electron in the same molecular orbital as the odd electron. It follows that the π-charges in carbonium ions are given by

$$q_r^0 = 1 - c_r^2, \qquad (3)$$

and in carbanions by

$$q_r^0 = 1 + c_r^2, \qquad (4)$$

where c_r is a coefficient the square of which gives the chance of finding the odd electron in the radical on atom r.

It will be shown in a forthcoming article[2] that the following rules give the coefficients c_r for a hydrocarbon radical with $2m + 1$ conjugated atoms.

(*a*) Draw any one of the principal resonance structures of the radical. Then provided the radical has just one unpaired electron, this structure will have just one trivalent carbon atom.

(*b*) Mark this atom with a star and every alternate conjugated atom throughout the molecule. When this process is complete there will be found to be $m + 1$ starred atoms and m unstarred atoms.

(*c*) Assign c_r the value zero for all the unstarred atoms.

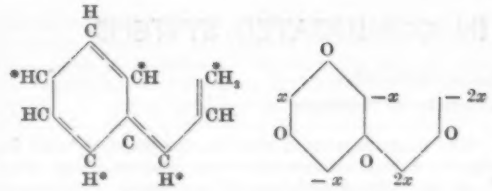
(*d*) For each unstarred atom the sum of the coefficients c_r at the neighbouring starred atoms must be zero. Therefore, if c_r is assigned the value x at a particular atom, the values of c_r at the other starred atoms may be found directly in terms of x.

(*e*) The absolute magnitudes of the numbers c_r are determined by the condition that

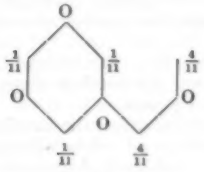
$$\sum_r c_r^2 = 1. \qquad (5)$$

As an example we shall calculate the π-charges in the phenylallyl anion. Formula I (p. 140) gives one of the principal resonance structures of the phenylallyl *radical*. The starring process gives five starred and four unstarred atoms. The coefficients c_r vanish at the unstarred atoms; and if c_r is assigned the value x at the *para*-position in the phenyl group, rule (*d*) may be used to write down the values of c_r at the other starred positions (see formula II). By condition (*e*),

$$\sum_r c_r^2 = 11x^2 = 1;$$



I II

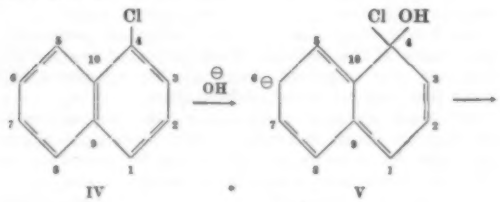


III

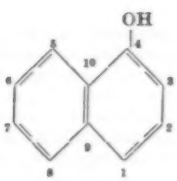
so the absolute values of c_r^2 are as given in formula III. By equations (3) and (4) these numbers also give the net positive and negative charges in the phenylallyl cation and anion. (It may be verified that if c_r had been assigned the value x at the CH_2 group, for example, the final result would have been just the same.)

Differences in Activation Energy

As one example to show how these ideas may be used in computing differences in activation energy, we shall discuss the hydrolysis of various 4-chloro-aza-naphthalenes, some of which have been studied recently by Morley, Simpson and their collaborators[3]. The general mechanism of these reactions is probably as follows:



IV V



VI

(Only one possible resonance structure has been drawn for each species.) In calculating unsaturation energies, it is probably a fair approximation to neglect the conjugation of the Cl atom with the aromatic residue in (IV) and also hyperconjugation involving position 4 in (V). Further, replacement of a particular CH group by N will affect the skeletal energies of (IV) and (V) to roughly equal extents; so any change in activation energy produced by aza-substitution may be ascribed to changes in unsaturation energy of the reactant and transition complex.

Let us denote the unsaturation energy of an aza-derivative of (IV) by E and that of the corresponding transition complex by E'. Then it is assumed that the difference in activation energy between the hydrolysis of (IV) and its aza-derivative is given by

$$\Delta U - \Delta U^0 \neq (E' - E) - (E^{0\prime} - E^0),$$

where E^0 and $E^{0\prime}$ are the unsaturation energies of (IV) and (V) respectively. But by equation (1)

$$E' - E^{0\prime} \neq \sum_r \alpha_r q_r^{0\prime}$$

and

$$E - E^0 = \sum_r \alpha_r q_r^0,$$

where α_r is the energy parameter for position r in the derivative and its transition complex, and q_r^0 and $q_r^{0\prime}$ denote the π-charges at position r in (IV) and (V) respectively. Therefore,

$$\Delta U - \Delta U^0 = \sum_r \alpha_r (q_r^{0\prime} - q_r^0). \qquad (6)$$

But $q_r^0 = 1$ at every position in (IV), and $q_r^{0\prime} = 1 + c_r^2$, by equation (5). Therefore, finally,

$$\Delta U - \Delta U^0 = \sum_r \alpha_r c_r^2. \qquad (7)$$

The values of c_r^2 for the complex (V) may be obtained directly from formula III, since (V) is isoelectronic with the phenylallyl anion. The parameters α_r will have values depending on which CH groups in (IV) are replaced by N. If it is assumed[4] that aza-substitution at position r produces a perturbation δ at that position and a perturbation $\delta/3$ at neighbouring positions, then the values of α_r in the aza-derivatives under consideration will be as given in the accompanying table.

In the extreme right-hand column are given the values of $\Delta U - \Delta U^0$, computed from equation (7) using the assumed values of α_r and the numbers given in formula III. These figures show that 4-chloro-aza-naphthalenes should be increasingly easily hydrolysed in the order

$$A \ll C < B, D \ll E, G < F.$$

Morley and Simpson have recently shown that the 4-chloro-derivatives of quinoline, cinnoline and quinazoline are hydrolysed to the phenols under conditions

		α_1	α_2	α_3	α_5	α_6	α_7	α_8	α_9	α_{10}	$\Delta U - \Delta U^0$
A	4-chloronaphthalene	0	0	0	0	0	0	0	0	0	0
B	4-chloro-1-aza-naphthalene (4-chloro-quinoline)	δ	$\delta/3$	0	0	0	0	0	$\delta/3$	0	$12\delta/33$
C	4-chloro-2-aza-naphthalene (4-chloro-isoquinoline)	$\delta/3$	δ	$\delta/3$	0	0	0	0	0	0	$8\delta/33$
D	4-chloro-3-aza-naphthalene (1-chloro-isoquinoline)	0	$\delta/3$	δ	0	0	0	0	0	0	$12\delta/33$
E	4-chloro-1 : 2-diaza-naphthalene (4-chloro-cinnoline)	$4\delta/3$	$4\delta/3$	$\delta/3$	0	0	0	0	$\delta/3$	0	$20\delta/33$
F	4-chloro-1 : 3-diaza-naphthalene (4-chloro-quinazoline)	δ	$2\delta/3$	δ	0	0	0	0	$\delta/3$	0	$24\delta/33$
G	4-chloro-2 : 3-diaza-naphthalene (4-chloro-phthalazine)	$\delta/3$	$4\delta/3$	$4\delta/3$	0	0	0	0	0	0	$20\delta/33$

in which 1-chloro-naphthalene would certainly not be hydrolysed. Their experimental results give the order

$$A \ll B \ll E < F.$$

Discussion

A more detailed exposition of the ideas outlined, together with a discussion of their validity and range of application in organic chemistry, is shortly to appear in the *Journal of Chemical Physics*. Suffice it to say here that calculations of this elementary nature can be applied to a wide range of organic reactions, and that the results can be proved to be consistent with those of classical electronic theory, provided no odd-membered rings are present. It is scarcely necessary to point out that the present quantitative theory suffers from the same limitations as the qualitative resonance theory, in that it takes no account of entropy changes or solvent effects; but the discussion of such phenomena lies beyond the scope of pure electronic theory.

Perhaps the most important feature of this new technique is that it enables the chemist to calculate *quantitatively* differences in reactivity almost, if not quite, as simply as he could previously estimate them qualitatively by resonance theory. Many gaps, of course, remain: we still do not know the parameters α_r for hetero-atoms with sufficient precision; no account is taken of steric factors; and the new technique cannot be applied to odd-membered ring systems. But it seems ideally suited for the prediction of relative rates of isoelectronic reactions in nitrogen heterocycles; and it is to be hoped that before long it will come to be used by experimental workers for interpreting their results and predicting new ones.

I wish to thank Drs. J. S. Morley and J. C. E. Simpson and their collaborators for allowing me to quote their unpublished results, and Prof. M. G. Evans for his valued encouragement.

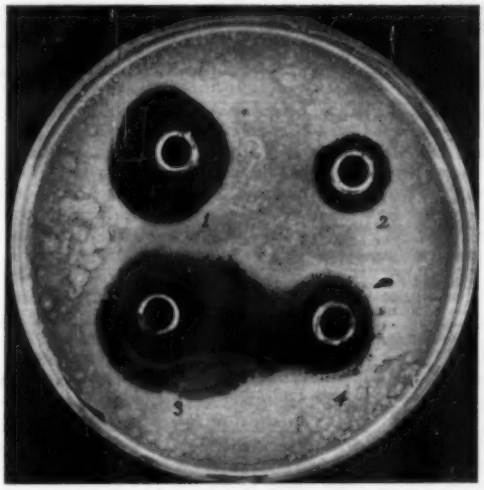
[1] Coulson, C. A., and Rushbrooke, G. S., *Proc. Camb. Phil. Soc.*, **36**, 193 (1940).
[2] Longuet-Higgins, H. C., *J. Chem. Phys.* (In the press).
[3] Morley, J. S., and Simpson, J. C. E., *Nature*, **164**, 105 (1949); *J. Chem. Soc.* (In the press).
[4] Dewar, M. J. S., *J. Chem. Soc.*, 644 (1949).

ANTIBACTERIAL ACTIVITY OF A SUBSTANCE PRESENT IN TICKS (IXODOIDEA) OF TEXAS

By Prof. LUDWIK ANIGSTEIN, DOROTHY M. WHITNEY and DON W. MICKS
Department of Preventive Medicine and Public Health, University of Texas Medical Branch, Galveston

EXCEPT for the biological vectors of specific pathogenic agents, arthropods as a group harbour a great variety of non-specific bacteria[1]. Among the factors influencing the type of bacterial flora, the feeding habits of the arthropod are of primary importance. In this regard the blood-sucking species occupy a singular position as having the fewest bacteria, or even showing sterility of the digestive tract[1].

The present study developed from our recent inquiry into the prevalence of rickettsial infections in 'wild' ticks of the Gulf area and from a bacteriological survey of these ticks. The scarcity or absence



Growth inhibition of *B. subtilis* by trypsin-digested extracts from *Ornithodoros turicata* as compared with the action of the antibiotic *Q* 19 ('circulin'). 'Penicylinder' assay technique 1, *Q* 19 ('circulin'); 2, extract from unfed ticks; 3 and 4, extract from engorged ticks

of bacterial organisms in the ticks stimulated us to investigate the underlying causes of this phenomenon, inasmuch as Duncan[2] by his original observations first indicated the presence of a bactericidal principle in insects and ticks.

Hard and soft ticks of Texas (*Amblyomma americanum*, *A. cajennense*, *Rhipicephalus sanguineus*, *Ornithodoros turicata*, *Argas persicus*) in the adult stage were investigated in the search for possible antibacterial properties. Parallel experiments were conducted with unfed and blood-engorged specimens, the latter feeding on cattle, guinea pigs, dogs, rats and chickens.

Aqueous extracts from ground tissues of pooled ticks were reconstituted from the previously lyophilized material on the basis of 0·1 gm. dry weight in 5·0 ml. of phosphate buffer (*p*H 7·8). This was followed by digestion with trypsin, which proved essential, particularly in handling the high-protein content of engorged ticks. In a series of experiments non-digested material was used for comparison. Prior to final tests, all samples were heated to 65° C. for 30 min.

As a representative test organism, *B. subtilis* was chosen for routine antimicrobial assays. In addition, other spore-bearing bacilli (*B. mesentericus*, *B. megatherium*, *B. cereus*, *B. anthracis*), as well as *Sarcina lutea*, *Staph. aureus*, *Staph. albus* and *Escherichia coli*, were tested. For qualitative and quantitative evaluation of activity of the tick extracts, some methods of the modern antimicrobial assays were applied: streak agar plates, paper disks, 'penicylinders', serial broth dilutions and spot dilutions on agar plates.

The first indication of antibacterial properties was obtained from the unfed *Amblyomma americanum*, dragged from ground vegetation of a heavily infested area. A complete or partial inhibition of growth of *B. subtilis* was demonstrated after placing a drop of tick extract on streaks of the spores. This phenomenon, constantly observed with extracts of the various engorged ticks, occurred with less frequency

QUANTITATIVE EVALUATION OF ANTIBACTERIAL ACTIVITY OF VARIOUS TICKS AGAINST *B. subtilis*

Material	Two-fold serial transfers of crude tick extracts in broth. End-points in decreasing concentrations								
	1 : 50	1 : 100	1 : 200	1 : 400	1 : 800	1 : 1600	1 : 3200	1 : 6400	1 : 12800
Amblyomma americanum engorged and digested	+	+	+	+	+	+	+	+	−
Same, not digested	+	+	+	+	+	+	−	−	−
A. cajennense engorged and digested	+	+	+	+	+	+	+	−	−
Same, not digested	+	+	+	+	+	+	−	−	−
Rhipicephalus sanguineus engorged and digested	+	+	+	+	+	+	+	+	−
Same, not digested	+	+	+	+	+	+	−	−	−
Ornithodoros turicata engorged and digested	+	+	+	+	+	+	+	+	+
Same, not digested	+	+	+	+	+	+	+	−	−
O. turicata unfed digested	+	+	+	+	+	+	−	−	−
Same, not digested	+	+	+	+	+	−	−	−	−
Trypsin alone in broth incubated at 37° C.	−	−	−	−	−	−	−	−	−

+, complete inhibition of growth; no visible growth of *B. subtilis*. −, no inhibition of growth; normal growth of *B. subtilis*. First tube contains 10 mgm. dehydrated crude extract in 0·5 ml. broth. Readings after 24-hr. incubation at 37° C.

when unfed specimens were used; however, the antibacterial activity of unfed *A. americanum*, *A. cajennense* and *O. turicata* was established by the various antimicrobial assay methods. The antibacterial activity of *O. turicata* (vector of relapsing fever in Texas) was exceptionally high, showing complete inhibition of *B. subtilis* as demonstrated in serial dilutions up to 1 : 12,800 (see table) and on flooded agar plates by extensive clear zones surrounding 'penicylinders' filled with the digested extract (see illustration). Similar results were obtained with *Argas persicus* collected from chicken houses; a bacteriostatic or bactericidal agent was found in this species by E. A. Steinhaus in 1943 (personal communication). In this series clear, bacteria-free spaces on agar plates resulted from contact with the proteolytic products, whereas the non-digested portion of the same material showed no activity. It should be emphasized that tryptic digestion of the tick material is indispensable not only for the liquefaction of the viscous, coagulated, bloody content of the ticks, but, as previously observed by Duncan[2], was found to intensify growth inhibition (see table).

Having no data as to the nature of the digestive enzymes of ticks, we can only presume that they resemble those of insects, the enzymes of which are adapted to their particular diet[3]. We may, therefore, anticipate that in ticks feeding exclusively on blood, protease is produced in abundance. Since protease of insects is of the tryptic type, the addition of trypsin as an extrinsic but homologous factor merely led to the continuation of enzymatic hydrolysis by the tick. It is therefore logical to assume that the chemical nature of the antibacterial substance (single or multiple) lies within the range of these proteolytic products.

Preliminary tests to determine the range of the antibacterial properties of the active principle showed a spectrum limited to *B. subtilis*, *B. mesentericus*, *B. megatherium*, *B. cereus* and *Sarcina lutea*.

Some other properties of the antibacterial substance have been determined. It resists dehydration *in vacuo* and remains active in a dry state when kept in air-filled sealed ampoules for at least several months in the refrigerator. It resists heat to 121° C. for 15 min. in liquid medium at *p*H 7·8–9·4, but the antibacterial factor is destroyed by heat at *p*H 5·7 or lower.

The higher activity of the material from engorged ticks suggested that blood may be the source of an additional antibacterial factor. For preliminary tests, guinea pig blood was used, since in a series of experiments this animal served as host of *Amblyomma americanum*. The blood was divided in two main portions: one was coagulated, while the other was defibrinated mechanically and centrifuged. Serum was separated from the cells, which were washed in sterile saline. Each component was lyophilized and either digested with trypsin or left untreated.

A total of ten blood samples was examined in various combinations, heated to 65° C. for 30 min. A complete inhibition of *subtilis* growth was noted on agar plate streaks with trypsin-digested cells and partial inhibition with digested whole blood. However, a complete absence of antibacterial activity of the fresh or heated serum was noted, which is of interest since the serum of various animals is known to contain non-specific thermostable substances such as beta lysins[4]. It is to be observed that the antibacterial properties of the blood were demonstrated by us only when proteolysis was applied. This would suggest that the antibacterial activity of the digested cells is associated with the enzymatic hydrolysis of proteins and liberation of peptides and perhaps free amino-acids. Independently, and at our request, the chemical nature of a sample representing desiccated material from engorged *A. americanum* has been investigated by Dr. Jorge Awapara, of the University of Texas, M. D. Anderson Cancer Research Hospital, Houston. The results of this work suggested that there were very few amino-acids and only one peptide detected in the crude tick extract. This peptide (*Y*) was stated by Dr. Awapara to be similar to or identical with the one found by him in human blood (personal communication).

Since the antibacterial factor found in ticks is considerably enhanced by the ingested mammalian blood, the question arises whether this phenomenon may have some bearing on the 'reactivation' of spotted fever rickettsiæ in Nature as formulated by Spencer and Parker in 1923 [5]. In reviving this almost forgotten theory, the ingestion of fresh blood is, according to these authors, essential to transform the non-virulent phase of the 'virus' of the unfed infected ticks to a virulent fever-producing phase. Some unrecognized condition initiated by the ingestion of

blood was assumed to play a part in this transition, which in our interpretation may be due to metabolic processes of the vector, inasmuch as *Dermacentor andersoni* requires up to forty-eight hours of attachment to the host to become infective. In the light of our observations this "unrecognized condition" might be caused by the enzymatic hydrolysis of blood proteins creating in the tick environmental factors unfavourable to bacteria, but suitable to the different metabolic requirements of parasitic rickettsiæ.

This work was aided by a grant of the Lilly Research Laboratories. An account of it was presented at a meeting of the Texas Branch, Society of American Bacteriologists, November 19, 1949, Austin, Texas.

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INTERNATIONAL CONVENTION ON ULTRASONICS

THE International Convention on Ultrasonics, held in Rome during June 14–17, represented a milestone in the progress of ultrasonics and was an achievement in many respects. There were about one hundred and twenty delegates from fourteen different countries, including Great Britain, the United States, France, Italy, Germany, Belgium, Holland and Switzerland. The Convention was organised by the Consiglio Nazionale delle Ricerche and the Societa Italiana di Fisica, supported by the International Union of Pure and Applied Physics and by the United Nations Educational, Scientific and Cultural Organisation. As was widely attested by delegates, much credit was undoubtedly due to Prof. A. Giacomini, director of the O. M. Corbino Institute of the Italian National Research Council, for the inspiration and planning of the Convention. The arrangements were admirable and the programme was carried out smoothly and expeditiously.

After an impressive official opening of the Convention at the Protomoteca Hall at the Capitol, with speeches by the Mayor of Rome, Prof. G. Colonnetti (president of the Italian National Research Council), Prof. P. Fleury (secretary of the International Union of Pure and Applied Physics) and Prof. Giacomini, the scientific proceedings took place in the O. M. Corbino Institute, a well-designed modern building comprising laboratories, offices, library and auditoria. The first paper gave a general account of the present ultrasonic work[1] at the Institute and the plans for future work there. Several of the applications described arose from the ultrasonic grating method of light control, this method being used for communication systems involving modulation of light beams, for accurate measurement of velocity in liquids, measurement of Poisson's ratio in solids and for demonstration of acoustic lenses, while a possible use for flaw detection was forecast. Other activities included an ingenious use of a simple microphone for measurement of pulsed ultrasonic radiation, and work on elastic constants and anelasticity of metals using ultrasonic vibrations.

Among the main representatives were Prof. F. E. Fox (United States), Dr. L. Bergmann (Germany), Dr. F. Canac (France), and Prof. A. van Itterbeek (Belgium), and among other well-known workers in the field of ultrasonics were: Messrs. Biquard, Grabar, Lucas, Prudhomme, Kneser, Schaafs, de Groot, R. Pohlmann and P. Bordoni. The delegates from Great Britain were Messrs. Bell, Bradfield, Crawford, Hillier, King, Pickles, Stephens and Stanford. The Convention was so well attended that, apart from combined sessions for subjects of common interest, it was found necessary to use two auditoria simultaneously, in one of which subjects mainly of interest in physics and technology were discussed, and in the other, applications to biology and medicine. In this way, time was found for a total of ninety communications to be made in the period of four days.

After Dr. J. W. F. Bell had given a brief account of the work[2] at Newcastle upon Tyne on errors in interferometry, the behaviour of carbon dioxide and ethylene near their critical points, and absorption in tubes, Dr. Bergmann, author of "Der Ultraschall"[3], gave an excellent survey of progress in ultrasonics, in the course of which he illustrated the Kelvin–Hughes and the Sperry ultrasonic flaw detectors, the American smoke-precipitating sirens and the Mullard ultrasonic soldering iron. Messrs. Chavasse and Lehmann then gave an account of the measurement and analysis of ultrasonic vibrations met in everyday life in aircraft engines and electric drills, and those emitted by insects.

In the fundamental field of physics, emphasis was laid on the value of ultrasonics for precision measurement of velocity, accuracies of 0·05 per cent being achievable; even in small specimens a few millimetres in length, 1 per cent accuracy is readily possible. The investigation of absorption in liquids is yielding valuable results on relaxation phenomena, and it seems possible that the association bonding energies of such organic components as acetic and propionic acids may be revealed by these means. Collision phenomena causing high absorption in binary liquid mixtures are being thoroughly investigated.

Relaxation phenomena in solids of the type discussed by Kê[4] involving viscous slip at grain boundaries are being investigated at temperatures near the melting point of, for example, aluminium, using ultrasonic frequencies. Measurements of piezoelectric and dielectric properties of materials such as barium titanate seem likely to provide valuable information on dipole properties in solids. The Bergmann–Schäfer technique for measuring elastic properties is now being successfully employed on transparent piezo-electric materials, including those of the ferro-electric type.

The complications arising when cavitation is present during ultrasonic propagation were emphasized. It was pointed out that if liquids are freed from air bubbles and other nuclei, cavitation does not take place; but at the same time the ability to produce emulsions and the lethal action on bacteria are much reduced. These effects seem to depend on the intense shock waves arising when cavitation voids collapse.

In technology the value of ultrasonic testing for flaws was emphasized, and experience of its use for many years in the aluminium industry was summarized. Success has been claimed for the ageing of spirits, for example, whisky, by ultrasonic irradiation. The usefulness of ultrasonic irradiation in the soldering of metals such as aluminium is now well

established. An interesting attempt was described to forecast by a model test using ultrasonics the performance at audible frequencies of an open-air theatre.

The widespread use of ultrasonics in biological investigation and in therapy is noteworthy. It appears that many hundreds of ultrasonic equipments for medical purposes costing £100–£400 apiece have been manufactured and are in use on the Continent of Europe. In contrast, it seems doubtful whether even a single equipment is used for this purpose in Great Britain. The total amount of equipment involved is probably comparable to that used for ultrasonic flaw detection throughout Europe, and the importance of this field is reflected in the fact that slightly more than 50 per cent of all the contributions to the Convention were on biology and medicine. At the exhibition of ultrasonic equipment which accompanied the Convention, it was noticeable that there was a great variety of therapeutic equipments preponderating over all other types of apparatus, even over that for flaw detection.

In biological applications the nature of the effect of ultrasonic radiation depends markedly on the intensity and on the frequency, which ranges from a few kilocycles to a few megacycles, and perhaps on whether pulsed radiation is employed. There appear to be broadly two effects, a heating effect and a mechanical effect. The former may differ markedly in its distribution from that when infra-red or radio short-wave radiation is used; for heat will be generated by the mechanical waves where absorption is most pronounced, while the depth of penetration will be less the higher the frequency employed. Thermal effects are more marked at high frequencies; but mechanical damage more often occurs at low frequencies.

At lower intensities the mechanical effects of irradiation appear to be to cause acceleration of chemical reactions, liquefaction of thixotropic gels and an increased permeability of cell walls and membranes to the passage of natural fluids. These lower intensities are of the order of $\frac{1}{4}$–3 watts/sq. cm. Above this level, prolonged irradiation causes irreversible changes and can break up the protein molecules themselves, as was shown by the investigations of several biological workers. Examples were cited of the irradiation of embryos, where the use of lower intensities accelerated development whereas higher intensity produced harmful and irreversible effects. The reaction of the nerve cells to radiation seems to involve a relaxation time, for it appears that the effect of stimulation continues even after the stimulus ceases. As a consequence, equipment has been developed which irradiates in successive bursts, the theory being that, while heating is reduced, the slowness of the physiological relaxation diminishes the effect of the gaps in transmission time, so favouring the mechanical effect in comparison with the heating effect.

It is impossible in this brief account to discuss adequately the thirty papers on medical aspects of the use of ultrasonics. Some forty maladies were listed which are believed to have benefited by irradiation. These range from treatment of abscesses, arthritis, asthma, ischias, carbuncles and lumbago to the treatment of neuralgia and spondylarthritis ankylopoietica Bechterew. In general, the intensity used is 1–5 watts/sq. cm., the treatment time varies from two to twelve minutes and the number of treatments from a few up to fourteen. Hundreds of treatments have been systematically examined, and there appears little doubt that benefit often results even in cases which have previously proved most obstinate to alternative treatments. G. BRADFIELD

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ASTRONOMY IN AUSTRALIA

REPORT OF THE COMMONWEALTH ASTRONOMER FOR 1949

THE report of the Commonwealth Astronomer for 1949* covers the year up to December 31 and is divided into the following sections: solar investigation, time service, astrophysical observations, Melbourne catalogue, 74-inch reflector, 48-inch reflector, workshop, ionospheric prediction service, publications, staff and general. As very full descriptions are given under the different sections, it is impossible to do anything more than notice a few of the more outstanding features in the report.

Time service and astrophysical observations (the latter including seven sub-sections) occupy more than one-third of the report. During 1939 three additional frequency-standards were installed at the Postmaster-General's Research Laboratories, three at the National Standards Laboratory and three at Canberra. Improved methods of forecasting clock errors were introduced, and the radiated signals are now self-consistent to within 2–3 milliseconds a day. Under the heading of astrophysical observations, it is satisfactory to learn that the spectrophotometric gradient observations of brighter stars were completed, and the results for 166 stars have been prepared for publication. The observations have provided increased precision to the blue end of the spectrum-colour relation, as some very blue southern stars were included, and this is important in the study of interstellar reddening and also of the stellar temperature scale. Many will await with interest the publication of the results of the galactic radio emission at a frequency of 200 Mc./s. on which observations have been made and corrections for aerial beam width applied.

Sir Howard Grubb, Parsons and Co. have the greater part of the heavy components of the 74-inch reflector ready for machining, and arrangements are being made for the contract for the supply and erection of the dome and building. The borosilicate glass disk for the 48-inch reflector has been cast by Messrs. Pilkington Bros., Ltd., and the optical work is in the hands of Messrs. Cox, Hargreaves and Thompson, Ltd. The Observatory workshop has been responsible for a number of major items, including: a three-prism slit spectrograph of dispersion 10 A./mm. at $H\alpha$, which has been mounted in the Reynolds reflector; plate holders; a set of photometric sectors and mountings; and photometric calibrating equipment, constructed for the faint-star magnitude programme. Mirrors have been resilvered, and also adjustments and repairs made to various instruments submitted by Government organisations in Canberra.

* Commonwealth Observatory, Canberra. Report of the Commonwealth Astronomer for the year 1949. Pp. 6. (Canberra: Commonwealth Government Printer, 1950.)

LETTERS TO THE EDITORS

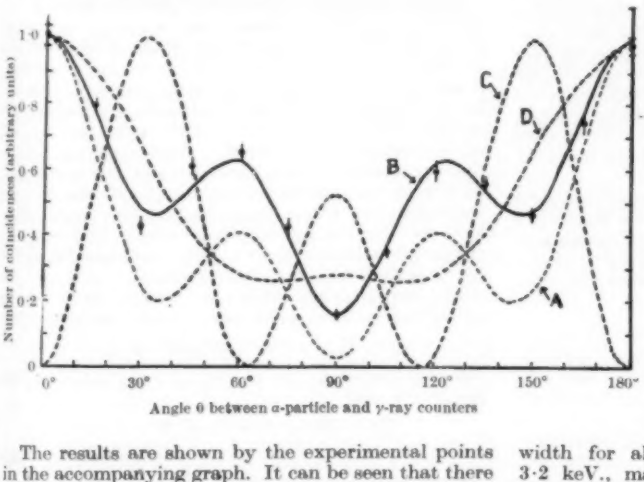
The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications

Angular Correlation Between α-Particles and γ-Rays in the Reaction $F^{19}(p,\alpha\gamma)O^{16}$

We have studied the correlation between the directions of emission of alpha-particles and gamma-rays at the 340-keV. resonance in the following reaction :

$$F^{19} + p \rightarrow Ne^{20*} \rightarrow O^{16*} + \alpha \rightarrow O^{16} + \gamma + \alpha.$$

Both alpha-particles and gamma-rays were observed in the plane perpendicular to the proton beam. The alpha-particles were detected in a proportional counter with a window sufficiently thick (approximately 6·5 mm. air equivalent) to exclude protons scattered from the calcium fluoride target. The 6·1-MeV. gamma-rays emitted from the oxygen-16* nuclei were detected in a lead-walled Geiger counter. Coincidences between the alpha-particles and the gamma-rays were measured as a function of angle between the counters.



The results are shown by the experimental points in the accompanying graph. It can be seen that there are terms as high as $\cos^6\theta$ and that there is approximate symmetry about the 90° direction. The presence of a $\cos^6\theta$ term requires that the orbital momentum l of the alpha-particle and the angular momentum j of the oxygen-16* nucleus must both be at least 3. In order to make a more detailed interpretation, it is first necessary to know the orbital momentum of the incoming protons. Evidence that this is zero is provided by the isotropy (with respect to the incident protons) of the alpha-particles[1] and gamma-rays[2].

If we assign to l and j their lowest possible values, namely, 3, and further assume the total angular momentum $J = 1$ for this resonance-level of neon-20*, we get the theoretical result indicated by curve A. When a correction is made for the finite solid angles subtended by the detectors ($\sim \frac{1}{50} \times 4\pi$), curve B is obtained. The close agreement between this curve and the experimental results supports the above assignment of angular momenta. The assignment $J = 0$ to the resonance-level which requires j and l to be equal leads for any value of j to an angular correlation function which is zero at $\theta = 0°$ and 180°. This conflicts directly with experiment as illustrated by curve C, which is drawn for $j = 3$. It is therefore impossible to attribute the isotropy of the alpha-particles and gamma-radiation, mentioned above, to a $j = 0$ level of neon-20. Two other feasible interpretations have been examined : (i) $J = 1$, $j = 4$, $l = 3$; this gives curve D. (ii) $J = 1$, $j = 3$, $l = 2,4$. Both components $l = 2$ and 4 can be present without producing terms higher than $\cos^6\theta$, and we must therefore consider the distribution produced by a coherent superposition of the $l = 2$ and 4 components. By a suitable choice of amplitude and phase relationships between these two components we can, in fact, produce a distribution function which agrees with experiment ; but this requires the contribution from $l = 4$ to be at least half that from $l = 2$, which is rather improbable.

We may therefore reasonably conclude that : (i) this resonance level of neon-20 is formed by $l = 0$ protons, has $J = 1$, and is probably of even parity because alpha-particle emission to the ground-state of oxygen-16 is not observed[3] ; (ii) since the neon-20* has even parity and is formed by $l = 0$ protons, fluorine-19 also has even parity ; (iii) the neon-20* emits alpha-particles with $l = 3$, leaving an excited oxygen-16 nucleus with $j = 3$ and odd parity.

Even parity for the ground-state of fluorine-19, and an excited state of oxygen-16 with $J = 3$, odd parity at 6·1 MeV., are both compatible with the alpha-particle model of the nucleus. The even parity of fluorine-19 is also in agreement with the central field model, which gives for this nucleus the configuration $^4S^{12}p^5d$. This model gives for the low excited states of oxygen-16 the configuration $^4S^{11}p^4d$, which includes the possible terms $^5D_3$, $^1F_3$ and $^3F_3$, all of the type $j = 3$, odd parity.

A difficulty that arises from these results is the interpretation of the observed width and cross-section of this resonance-level in neon-20. Measurements[4,5] indicate a combined width for alpha-particle and proton emission of 3·2 keV., made up of one width of 40 eV. and the other of 3·16 keV. The larger of these two widths (usually attributed to the alpha-particle) is difficult to reconcile with the small barrier-penetrability to be expected for either protons of such low energy or alpha-particles of such high angular momentum. This may indicate the inadequacy of some of the approximate methods used to calculate penetrability factors for particles of non-zero angular momentum[6].

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Chemical Effects of Ionizing Radiation in some Gels

We have previously studied the chemical changes produced by radiation in aqueous solutions and especially the use of such changes for radiation 'dosimetry', that is, the measurement of the energy absorption of ionizing radiations[1]. In the search for a suitable system which would enable three-dimensional distributions of absorbed energy to be demonstrated, we have experimented with gels containing dyes which are reduced with change of colour on irradiation. Various phenomena have been observed, apparently bearing also on the biological action of ionizing radiation and perhaps on electron-capture processes in general.

For 'dosimetric' purposes, the system must be quasi-solid, should give a chemical change which is easily observed, and have the same average atomic number and electron density as body tissue (that is, as water). Suitable dyes which have been studied include methylene blue[2] and phenol-indo-2 : 6-dichlorophenol, which are decolorized, and we also observed that Folin's phenol reagent becomes coloured on irradiation. Gelatine or agar were used to form the gel in water, and the concentration of the dye was of the order of 0·001 per cent. The quantitative yields obtained at this low concentration show that the effect is not of a photochemical, but rather of a 'radiation chemical' nature, where almost all the change finally observed in the dye is due indirectly to energy absorbed in the rest of the aqueous system. We have investigated the dependence of the yield on *p*H, concentration of dye and gelling material, and of oxygen and carbon dioxide.

Closely similar changes are observed in gelatine and agar. Oxygen, if present, competes with the dye for the reducing agent. In the case of methylene blue (Fig. 1), there is rather a sharp break in the curve when all the oxygen is reduced[1,3], whereas the indo-phenol dye (Fig. 2), which has a higher reduction potential, shows a rather more equal sharing of the available reducing agent, giving a more gradual change in the curve when all the oxygen is reduced. In the absence of oxygen and carbon dioxide, the curves are approximately linear until the dye is almost completely reduced. The linearity makes these reactions suitable for the quantitative determination of dose. Comparatively high gelatine or agar concentrations do not appear to compete appreciably with the dye for the reducing agent. This may be compared with the known great radiosensitivity of living tissues and certain enzymes[4].

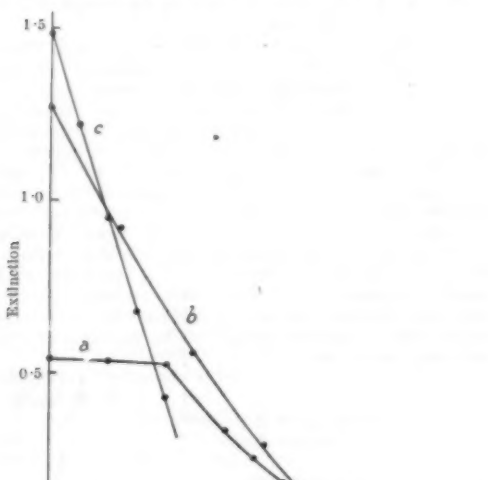

Fig. 1. Irradiation of methylene blue. (*a*) In presence of air; (*b*) in absence of air; (*c*) in absence of air with 1·6 per cent sodium benzoate added

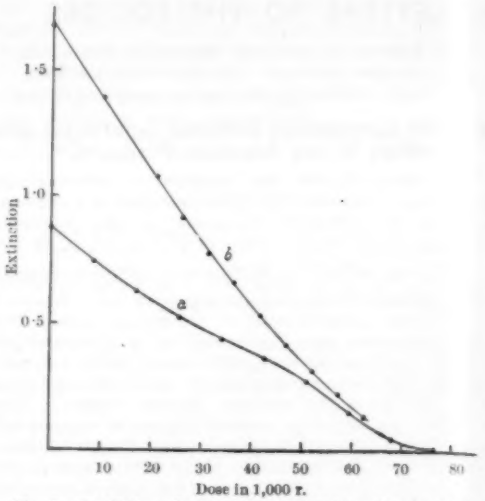

Fig. 2. Irradiation of phenol-indo-2 : 6-dichlorophenol. (*a*) In presence of air; (*b*) in absence of air

The action of radiations on aqueous solutions is considered[4] to proceed by way of a primary ionization.

$$(1)\quad H_2O \longrightarrow H_2O^+ + e,$$

followed by formation of hydroxyl radicals from the the H_2O^+, and

$$(2)\quad H_2O + e \rightarrow H_2O^-,$$

leading to the formation of hydrogen atoms from the H_2O^-.

While this is certainly the case in aqueous solutions in general[5], our results seem to suggest that the additional reactions

$$(3)\quad O_2 + e \rightarrow O_2^-$$

and

$$(4)\quad (\text{dye}) + e \rightarrow (\text{dye})^-$$

may compete with reaction (2) for the ionization electrons. The relative extent of these reactions will depend on the various electron affinities, and it is possible that very low concentrations of a suitable acceptor may capture practically all the electrons.

Our view that direct electron capture is playing a part in radiation chemistry may be collated with the findings of other workers that carotene dissolved in anhydrous fat or hexane is decolorized[7], and ferric iron in ether is reduced, by ionizing radiations[8]. Since, however, in these solvents the possibility of hydrogen atoms being formed still exists, we have carried out experiments in carbon tetrachloride and shown, for example, that the indo-phenol dye is reduced. It seems that although the action of ionizing radiation may under certain conditions be entirely

due to free radicals, in other cases it may be due, at least in part, to direct electron capture.

We have observed several re-oxidation phenomena, apparently due partly to the hydroxyl radicals and partly to oxygen (produced on irradiation or by diffusion from the air) as well as to O_2^- formed if oxygen is present during the actual irradiation. These effects may be related to certain biological effects of radiation, and may be compared with recent work on the role of O_2 and O_2^- in oxidation processes, involving semiquinones[8].

Fig. 3. 200-kV. X-ray beam in tissue-like 'phantom'. Diaphragm defining beam, 11 cm. diameter. Photograph reduced to half linear dimensions

A suitable system for our original purpose of dosage determination consists of 0·003 per cent methylene blue in 1 per cent agar, with the addition of 1 per cent benzoate to capture the hydroxyl radicals and so to increase the yield. Nitrogen, which apparently does not interfere, is bubbled through the hot gel to free it from oxygen, and it is then introduced into an appropriately shaped 'Perspex' vessel and allowed to solidify. Fig. 3 shows the picture obtained by irradiating such a vessel with an X-ray beam. We believe that the method may well find application in the measurement of three-dimensional distributions of absorbed radiation. Since the colour is formed without the addition of further reagents, it may also in some cases be preferable to previous methods for the chemical measurement of radiation.

Full details will be published elsewhere.

We wish to thank Dr. F. T. Farmer and Dr. Joseph Weiss for their support of this work and for many valuable discussions, and Dr. L. H. Gray for helpful suggestions.

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A Correlation of Restoring Coefficients in Molecular Potential Functions and Bond Orders Between the Different Atoms in Polyatomic Molecules

By re-investigating the Raman spectrum of C_2N_2 we have obtained, in addition to the frequencies already known[1], four more frequencies: 521·4 cm.$^{-1}$, 561·4 cm.$^{-1}$, 841 cm.$^{-1}$ and 2298·4 cm.$^{-1}$. The last one, which appears as a weak satellite to the very strong 2328·5 cm.$^{-1}$, is most probably an isotope line due to $C^{12}C^{12}N_2^{14}$, and enables us to calculate the complete harmonic potential function using some infra-red frequencies also[2]. In order to get an interpretation of the physical nature of the potential function, it is helpful to calculate the forces called into action on different atoms i by special atomic displacements. Considering only displacements, Δx, along the axis of the linear molecule, these forces are given by

$$K_{ij} = -\left(\frac{\partial V(x_{j'})}{\partial x_i}\right)_{xj=\Delta x}.$$

If the potential function is analysed in this way, the forces between the atoms appear to be independent of the order in which we arrange the two carbon atoms and the two nitrogen atoms along a straight line. Thus it is possible to decide which atoms are most strongly bonded and hence to determine the structural formula, NCCN, without ambiguity.

Restoring coefficients between the atoms i and j defined by

$$k_{ij} = \frac{dK_{ij}}{dx}$$

may be calculated also from the bond orders, p_{ij}, obtained by the method of linear combination of atomic orbitals. According to Coulson[4], the bond order is defined by

$$p_{ij} = \sum_m c_{im}\, c_{jm},$$

where c_{im} is the coefficient of the atomic wave function, φ_i, in the expansion of the molecular function, Φ_m, and the summation is performed for all occupied molecular orbitals. We now assume this definition to be valid also for non-adjacent atoms, thus giving us a measure for the direct interaction forces between the atoms i and j. Further, it seems reasonable to assume the restoring coefficient (k_{ij}, defined as above) to be directly proportional to p_{ij}, but inversely proportional to the distance, d_{ij}, between the two atoms. By applying the formula

$$k_{ij} = k_{ij}^* \cdot \frac{d_{ij}^*}{d_{ij}} \cdot \frac{p_{ij}}{p_{ij}^*},$$

where the starred quantities designate known values taken from one molecule, we are able to calculate the restoring coefficient, k_{ij}, for the direct interaction force between two atoms of the same kind in other molecules. In this way we have calculated the restoring coefficients for the NCCN-molecule (the atoms being numbered 1 to 4) from the known values of the restoring coefficients, interatomic distances, and bond orders in HCN, N_2 and C_2H_2. The accompanying table shows the agreement between the 'spectroscopic' and the 'theoretical' restoring coefficients (given in 10^5 dyne/cm.$^{-1}$).

	k_{12}	k_{13}	k_{14}	k_{23}
k_{ij} from the spectra	+16·58	+1·02	−0·96	+6·24
k_{ij} from the method of linear combination of atomic orbitals	+16·75	+1·05	−1·10	+6·48

Considering the approximate nature of the method of linear combination of atomic orbitals, this surprisingly close agreement must, of course, be regarded as fortuitous. However, calculations based on data given in the literature seem to support the general validity of the proposed relation between bond order and restoring coefficient. It may, therefore, be useful also for calculations of potential functions as for control of approximations used in the method itself.

A detailed report will be published in *Acta Chem. Scand.*

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X-Ray Analysis of the Swelling of Wood Pulp in Sodium Hydroxide Solution

Investigations[1] on the hydrolysis and water-regaining properties of wood pulp, cotton and cotton linters swelled in sodium hydroxide solutions of varying concentrations showed that, whereas for wood pulps a low constant-limit degree of polymerization and high constant water-regain were reached by swelling in an 8 per cent lye, it was necessary to swell cotton and cotton linters in a 10 per cent solution in order to obtain a similar result. These differences between swollen samples of the two fibres might be due to easier mercerizing, that is, transformation of the cellulose I lattice into the cellulose II lattice, in the case of the wood pulp as compared with the cotton linters.

The mercerizing of cotton fibres has been subject to a number of investigations[2,3,4], and at the temperature employed in our work the cotton will show a mixed cellulose I – cellulose II X-ray diffraction pattern when swelled in sodium hydroxide solutions of between 9·5 and 10·5 per cent. Below this range cellulose I, and above this range cellulose II, patterns are observed. Few investigations have been carried out on wood pulp fibres. Katz and Seiberlich[5] found at 18° C. that the mercerizing strength of sodium hydroxide was 15 per cent for cotton and only 11·25 per cent for wood pulps. They claim that fibres with a higher degree of polymerization are more difficult to mercerize than those of lower degree of polymerization, thus accounting for this difference between wood pulps and cotton fibres.

It was thought to be of interest to compare the X-ray diffraction patterns of pulp samples swelled in the range of sodium hydroxide solutions where the rather abrupt changes in the hydrolysis and water-regains are observed. Two sodium chlorite bleached pulps, 1,556 and 1,597, with degrees of polymerization of 1,700 and 1,300, respectively, were swelled in sodium hydroxide solutions varying in concentration between 5·5 and 8·0 weight per cent at 3° C. as described by Jörgensen[1]. For the X-ray diffraction work the fibres were carefully arranged to give complete random orientation and irradiated in a Debye-camera in a hydrogen atmosphere with a copper $K\alpha$ beam.

The X-ray diffraction diagram of pulp 1,556 swelled in 5·5 per cent lye exhibits an unchanged cellulose I pattern, whereas the diagram for that from 6 per cent lye shows partial mercerization. The formation of cellulose II at the expense of cellulose I is indicated from the decrease of the intensities of the 101 and $10\bar{1}$ interferences of cellulose I and from the increase in the intensity of the 121 interference of cellulose I caused by the superposition of the $10\bar{1}$ interference of cellulose II. For samples swelled in 7 and 7·5 per cent lye a steady increase in the amount of cellulose II is indicated by the appearance of the 101 interference of cellulose II and further decrease in the intensities of the 101 and $10\bar{1}$ interferences of cellulose I. The 8 per cent sample exhibits the pure cellulose II diagram.

The mercerizing of pulp 1,597 is retarded as compared with 1,556, as the 6 per cent sample gives an X-ray diagram showing very little change towards cellulose II. Again, the 6·5 and 7·5 per cent samples show diffraction diagrams of the mixed cellulose I and cellulose II patterns, and the 8 per cent sample has a pure cellulose II diagram.

Limit D.P., Water-Regain and X-Ray Evidence for Wood Pulps Swelled in Alkaline Solutions of Varying Concentrations

Swelling solution (weight % NaOH)	Pulp 1,556 (D.P. = 1,700)			Pulp 1,597 (D.P. = 1,300)		
	Water-regain (%)	Limit D.P.	X-ray evidence	Water-regain (%)	Limit D.P.	X-ray evidence
0	6·5	240	Cell. I	6·6	225	Cell I
5·5	6·6	140	Cell. I	7·7	115	Cell. I
6·0	8·3	95	Cell. I & II	8·1	75	Cell. I
7·0	8·4	80	Cell. I & II	8·3	75	Cell. I & II
7·5	8·7	75	Cell. I & II	8·7	65	Cell. I & II
8·0	8·8	55	Cell. II	8·8	55	Cell. II

The accompanying table shows that the X-ray analysis of the two pulps is in full agreement with the hydrolysis and water-absorption properties, which are seen to be sensitive indicators of any intracrystalline swelling. Note that the limit degree of polymerization may drop to half its original value without change in the X-ray diffraction pattern.

Wood pulps are undoubtedly more easily mercerized than cotton and cotton linters[1]. This difference cannot be explained on the basis of the lower degree of polymerization of the pulps[6], because the 1,556 pulp had a degree of polymerization similar to that of cotton linters. It seems to be more plausible to base an explanation on a possible difference in crystallite dimensions. The pulp of lower degree of polymerization (1,597) seemed to be more difficult to mercerize partially than the material of higher degree of polymerization (1,556). This indicates that the transition of cellulose I to cellulose II is dependent also upon the intercrystalline network, in that long cellulose chains extending through and connecting the crystallites facilitate the transformation to the cellulose II lattice. Details of this work will be published elsewhere.

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Age of Extremely Ancient Pegmatites from South-eastern Manitoba

In the determination of the geological ages of minerals by radioactivity methods, much attention is being given to those ages which are of the greatest antiquity. There are several reasons for this. The age of the oldest mineral sets a minimum value for the age of the earth; also a probable minimum age is set for the solar system and extra-terrestrial matter in general. A bottom 'rung' is given for any stratigraphical age column, and these great ages are of value when attempting to draw up possible maximum life-spans for the evolution of living organisms to their present state of complexity. In areas of extreme antiquity, suitable minerals may be used for the indirect determination of the decay constants of potassium[1]; furthermore, areas of greatest age are the most suitable places for seeking possible undetected radioactivities (for example, indium-115[2]). Consequently, it is highly desirable that these greatest ages be known accurately and that several checks be made.

Measurements made by the lead method (see discussion of several determinations by Holmes[3]) and the strontium method[4] show the age of pegmatites from south-eastern Manitoba as the greatest thus far measured. A like age is found by Hurley[5], using helium age determinations, for an east–west orogenic belt of infolded rocks in Ontario: the area of granites and pegmatites from south-eastern Manitoba lies on this east–west belt if extended westward. Holmes[3] calculates an age of $1{,}985 \times 10^6$ years from lead/uranium data, from uraninite, and Ahrens[4] finds $2{,}100 \times 10^6$ years based on the strontium/rubidium measurements on four specimens of lepidolite. The agreement is very good; but neither measurement can be regarded as wholly satisfactory. For the calculation of the lead age, some corrections have had to be applied[3], whereas the strontium ages, although undoubtedly of the right magnitude, are not precision measurements.

New measurements have been made, using the strontium method applied to a specimen of lepidolite. Recently developed spectrochemical methods (in preparation for publication) were used for the analysis of rubidium and of strontium.

Apart from the random error in any method of analysis, a spectrochemical procedure frequently introduces a systematic error because of the use of synthetic standards. In the present determinations, however, systematic error is believed to be absent, and there is only a relatively small random error (see below). Five determinations of rubidium and nine of strontium were made (see table).

Lepidolite from the Winnipeg River, South-eastern Manitoba

Rubidium (%)	Strontium (%)
2·56	0·020
2·56	0·017
2·60	0·023
2·78	0·020
2·64	0·014*
	0·019
Mean 2·64 (± 0·06)	0·025
	0·016
	0·030*
	Mean 0·0205 (±0·0012)

* These two deviations are unusually large for this method; whether or not they are included in the calculation of the mean matters little, however.

Strontium concentrated from the specimen of lepidolite was shown by mass spectrographic analysis as more than 99 per cent radiogenic. This analysis was made by W. T. Leland in A. O. Nier's laboratory at the University of Minnesota.

For the calculation of the age of the specimen, the mean ($5{\cdot}9 \times 10^{10}$ years) of the half-lives of rubidium-87 given by Eklund[6] ($5{\cdot}8 \times 10^{10}$ years) and Haxel, Houtermans and Kemmerich[7] ($6{\cdot}0 \times 10^{10}$ years) was employed. The age works out at $2{,}400(2{,}380) \times 10^6$ years.

This measurement replaces the earlier more approximate strontium measurements. Agreement is reasonably good with these earlier strontium measurements and with the lead measurements, and there seems no doubt whatever about the great age of the pegmatites.

The difference of 400×10^6 years between the new strontium age and the lead age does, however, seem large enough to be significant. At this stage the reason for the discrepancy is not apparent. Further lead age-determinations which are thoroughly reliable (no correction necessary) on relatively fresh uraninite are highly desirable; precise checking of the half-life of rubidium-87 is also desirable.

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Use of Plastics in the Fresnel Rhomb

In this note the suitability of the new optical plastics for use in the Fresnel rhomb is discussed. Because the polarizing angle for a dielectric-to-air surface varies very little with change of frequency, and its polarizing properties are affected less by surface deterioration and the presence of films than is the case with metallic surfaces, polarization by internal reflexion remains the most satisfactory means of producing circularly polarized white light. The problem exists as to what is the most suitable non-metallic medium for this purpose. It is hoped that the following considerations will show that choice is not restricted to the classical glasses adopted since Fresnel's time.

The essential requirement of the polarizing medium is that its refractive properties will permit the realization of the necessary phase difference, $\pi/2$, between the components of the incident vibration, preferably at a single reflexion. This requires the satisfaction of the relationship[1]

$$\Delta = \frac{\pi}{2} = 2 \tan^{-1} \frac{\cos i \, (\sin^2 i - 1/n^2)^{1/2}}{\sin^2 i},$$

where i is the angle of incidence and n is the refractive index of the medium for light passing to it from air. It follows that Δ cannot exceed $2 \tan^{-1} (n^2 - 1)/2n$, and a phase difference $\pi/2$ can be produced by a single reflexion only when n is not less than 2·414. Diamond, $n_D = 2{\cdot}417$, is ideally suited for this purpose. Because of the inherent disadvantages of such

highly refractive materials for use in prisms, however, it has been necessary to employ two internal reflexions, preferably at the same angle of incidence to prevent deviation of the light beam, as is done in the Fresnel rhomb.

The medium most suited for use in the polarizing rhomb, in addition to being of low dispersion, must possess a refractive index such that $d\Delta/di = 0$, to minimize errors in phase difference due to any incorrect adjustment of the angle of incidence. Since the dispersive powers of the common glasses vary approximately proportionally to their refractive indices, and as $\Delta_{max.} = \pi/4$ when $n = 1{\cdot}497$, $n_D = 1{\cdot}497$ and $\varphi = 51° 47'$ are the most suitable refractive index and angle for the rhomb respectively. In practice, however, for stability reasons it is customary to use a 54°-prism constructed from the least refractive of the stable borosilicate crown glasses for which $n_D = 1{\cdot}51$, although $n_D = 1{\cdot}49$ is within the range of refractive index of the seldom used and less stable fluor crowns.

The low dispersive optical plastics, because they possess a refractive index in general less than that of glass, usually in the range 1·49–1·50, are ideally suited for rhomb construction. A number of satisfactory rhombs have been made in the various media of this class now available.

For precision work, these prisms suffer from the defects at present common to the optical plastics, due to the instability of their surfaces and their ability to absorb water vapour; in addition, a certain amount of light scattering is apparent. It is hoped that in the future these difficulties will be overcome. For the present the plastic rhombs possess many advantages for demonstration and student use, one of which is that they can be readily constructed in laboratories where glass-working equipment is not available.

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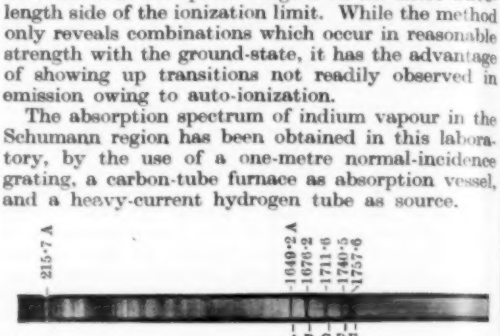
Absorption Spectrum of Indium Vapour in the Schumann Region

The ground-state of the indium atom is $5s^2\ 5p\ {}^2P^0_{1/2}$, and the term system responsible for the ordinary series spectrum—that is, the system built on the $5s^2\ {}^1S_0$ ground-state of the ion—was summarized and extended by Paschen[1]. Also included in his list are the following three terms: $5s5p^2\ {}^4P$, $5s5p^2\ {}^2D$ and $5s5p6s\ {}^4P$. Of these, the first-named was originally identified by Sawyer and Lang[2] and by Lansing[3] independently, and seems well established; the other two terms are much more tentative. The sp^2-configuration should give other, hitherto unidentified terms, ^2S and ^2P, remembering that the use of Russell-Saunders symbols is merely conventional, as we are dealing with a case which probably departs markedly from LS-coupling. Rough estimates indicate that these terms, and those of other configurations in which two electrons are excited, will lie above the normal ionization potential.

It is well known from Beutler's studies of a number of elements[4] that a profitable method of seeking certain of such highly excited terms lies in observation of the absorption spectrum of the vapour of an element in the spectral region on the short wavelength side of the ionization limit. While the method only reveals combinations which occur in reasonable strength with the ground-state, it has the advantage of showing up transitions not readily observed in emission owing to auto-ionization.

The absorption spectrum of indium vapour in the Schumann region has been obtained in this laboratory, by the use of a one-metre normal-incidence grating, a carbon-tube furnace as absorption vessel, and a heavy-current hydrogen tube as source.



The accompanying reproduction shows a typical spectrogram, obtained at a furnace temperature of 1,250° C. The hydrogen tube yields a continuum down to 1650 A., and extending below this, the closely packed many-line spectrum of H_2. Five intense absorption lines can be seen in the region 1600–1800 A. At a furnace temperature of 950° C., the lines labelled *A*, *B*, *C*, *E* are intense, line *D* just visible, becoming plain at 1,100°. The lines *A* and *C* are fairly sharp, *B* and *D* rather diffuse and *E* very diffuse. At 1,400° a further diffuse absorption line, *F*, occurs upon the many-line spectrum at 1318 A., and the series lines $5^2P^0_{1/2} \rightarrow m^2D_{1/2\ 3/2}$ up to $m = 23$, as well as the series limit continua, are then seen plainly in absorption.

While the results of initial measurements of the six far ultra-violet lines are not of high accuracy, the wave-number intervals, combined with considerations of the character of the lines and probable coupling conditions, lead to the tentative conclusion that lines *A* to *D* represent the *PP′* multiplet $5^2P^0 \rightarrow 5s5p^2\ {}^2P$, and *E* and *F* are respectively $5^2P^0_{3/2} \rightarrow 5s5p^2\ {}^2S_{1/2}$ and $5^2P^0_{3/2} \rightarrow 5s5p6p\ {}^2S_{1/2}$. Four new levels are thus identified:

$5s5p^2\ {}^2P_{3/2}$ — 13964 cm.$^{-1}$ $5s5p6p\ {}^2S_{1/2}$ — 31421 cm.$^{-1}$.
${}^2P_{1/2}$ — 12989
${}^2S_{1/2}$ — 12439

The observation of the diffuse series up to $m = 23$, noted above, represents an addition of nine members to those recorded by Paschen. However, it is doubtful whether accurate measurement of these is possible on the low-dispersion pictures so far obtained; an attempt to use a higher-dispersion quartz instrument may be made later.

A full account of the work described and details of further experiments in hand will be published elsewhere.

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The Scintillation of Stars

In a recent communication in *Nature*[1], Dr. A. H. R. Goldie has suggested that the scintillation of stars may be associated with waves at an interface between two currents of air which have a difference of temperature of the order of 5–7° F. "Such waves," he writes, "should not uncommonly have an amplitude of the order of up to 500–1,000 ft. at the interface, wave-length up to 10 miles or more, speed anything up to 40 ft. per sec., but probably usually lower."

It does not seem likely that these waves are the cause of scintillation, for the following reasons. If these waves travel at usually not more than 40 ft. per sec. and have a wave-length of 10 miles, then three wave crests will pass a given point in one hour. Now stars twinkle at different periodicities, and in the case of Sirius each cycle has a duration of roughly 1 sec. and other stars are not very different. If this cycle is caused by air waves of ten miles wave-length, their rate of travel would have to be about one thousand times faster than that suggested by Dr. Goldie. Alternatively, if the speed he has suggested is correct, then the wave-length would have to be correspondingly shorter, say about 50 ft.

Apart, however, from the fact that the waves described by Dr. Goldie do not appear to have either the correct speed or the correct wave-length to fit in with the cycle of star scintillation, I have shown in previous letters that even if there were waves which did fit in with the cycle, they still would not produce the phenomena associated with scintillation. It would be expected that the waves would produce (*a*) clearly marked side shifts at right-angles to the long axis of the waves, and (*b*) spectra, owing to dispersion of light at the interface between the two air currents. But neither of these phenomena is to be found. What we do see when we look at stars are changes in light intensity and changes in colour, from pink through white to a pale blue-green. But neither the one nor the other can be adequately explained on the basis of air waves.

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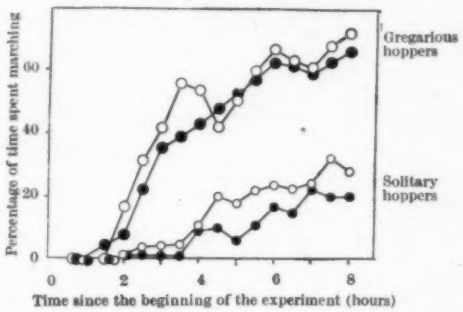
Marching in Locust Hoppers of the Solitary Phase

Locust species exist in two phases differing in colour, anatomy and behaviour with intermediate forms between the two extremes[1,2]. The nymphs (hoppers) of the gregarious phase are black and orange in colour; they congregate and wander or march in bands. Hoppers of the solitary phase are green or brown; they live in isolation and do not march. In the laboratory, the two phases can be produced by crowding or isolating the individuals during rearing.

Some field records mention green hoppers in gregarious bands; but it is generally assumed that marching is characteristic of the gregarious phase only. Kennedy[3] first suggested, and Volkonsky[4] put forward a definite hypothesis, that hoppers of the solitary phase also possess the necessary mechanisms for marching, the difference between the two phases being only quantitative.

It is now possible to obtain marching in cages, and I have compared the marching behaviour of fourth instar hoppers of the two phases of *Locusta migratoria migratorioides* (R. & F.). Gregarious hoppers had gregarious parents, and solitary hoppers, solitary parents. The results confirm that marching is a behaviour pattern not of the gregarious phase only, but of the locust species as a whole. There is, however, a clear quantitative difference between the two phases, solitary hoppers marching for less of the time, and at lower speeds, than hoppers of the gregarious phase.



In the first group of experiments, eighteen hoppers of the same phase were put together in a cage, and the percentage of time spent marching recorded for marked individuals. The accompanying graph gives the results for two experiments on each phase, and shows that solitary hoppers march, but for less of the time than gregarious hoppers. During the last three hours of these experiments, the speeds of hoppers while marching were recorded. The averages of twenty results for each phase are shown in Table 1. The difference is significant; hoppers of the solitary phase march more slowly than those of the gregarious phase.

Table 1. Marching Speed (cm. per sec.)

Solitary hoppers.	Mean 1·65 cm. per sec.	1·5	S.D.	1·45	
Gregarious ,,	,, 3·67 ,,	,, ,,	1·8	S.D.	1·89

Difference between the means, 8·78 times the standard error of the difference and thus significant.

In the second group of experiments, single marked solitary and gregarious hoppers were dropped into a cage of marching gregarious hoppers, and their activities noted for a specified length of time. The average percentage of time spent in marching for each hopper was calculated, and the results analysed statistically (Table 2). These results show that solitary hoppers are capable of joining a marching stream, but there is again a quantitative difference between the two phases.

Table 2. Percentage of Time Spent Marching

Solitary hoppers.	Mean 26·1%	3·8%	S.D.	16·1	No. of cases	18
Gregarious ,,	,, 49·2%	2·6%	S.D.	15·0	,, ,,	33

Difference between the means, 5·05 times the standard error of the difference and thus significant.

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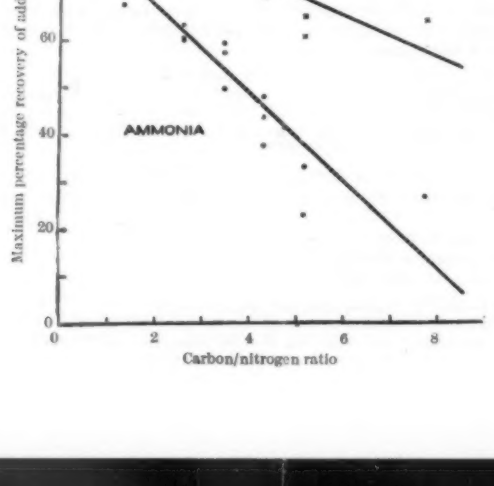
Effect of Carbon/Nitrogen Ratio upon the Formation of Nitrate and Ammonia from Amino-acids in Soil

In the course of an investigation into the decomposition of nitrogenous materials in the soil, we have in one experiment found a highly significant correlation between carbon/nitrogen ratio and the formation of both ammonia and nitrate from a series of amino-acids added to the soil.

The importance of the carbon/nitrogen ratio in relation to biological processes in the soil has long been recognized[1,2]. Working with amino-acids, Batham[3] reported that nitrification appeared to be independent of carbon/nitrogen ratio, but later[4] observed a fairly close relationship for nitrogenous compounds more complex than the monoamino-monocarboxylic acids. More recently, Quastel[5] reported that for glycine, alanine and sodium glutamate, recovery of added nitrogen as nitrate was inversely related to carbon/nitrogen ratio.

In the present experiment the following sixteen amino-acids were used: L-arginine hydrochloride, L-histidine hydrochloride, L-glutamic acid, L-tyrosine, L-lysine hydrochloride, L-proline, DL-alanine, DL-tryptophane, DL-serine, DL-valine, DL-leucine, DL-*nor*-leucine, DL-threonine, DL-aspartic acid, α-amino-*iso*-butyric acid and glycine. Each amino-acid was mixed with market-garden soil in quantities calculated to supply 300 p.p.m. nitrogen, except for histidine, lysine and arginine, which were at concentrations of 275, 273 and 248 p.p.m. respectively. The soil was kept in an incubator at 23·5° C. and each batch sampled at least nine times over a period of twenty-five days, analyses being made for ammonia and nitrate. From the results, the maximum values for percentage conversion to ammonia and nitrate were obtained for each amino-acid and plotted against the carbon/nitrogen ratio, as in the accompanying graph.

Taking the carbon/nitrogen ratio as the independent variate (y), the equation to the regression of ammonia (x) on the carbon/nitrogen ratio is $X = 86{\cdot}0 - 9{\cdot}36y$ and the correlation coefficient r is $-0{\cdot}91$. Nitrate values (x_2) for only fourteen amino-acids were available, as the quantities of threonine and proline proved insufficient to allow completion of the experiment. The regression equation is $X_2 = 91{\cdot}9 - 4{\cdot}45y$ and again r is $-0{\cdot}91$, showing a highly significant correlation.



It is evident from these results that the effect of carbon/nitrogen ratio is more marked on accumulation of ammonia than of nitrate. If the occurrence of ammonia and afterwards of nitrate in the soil during decomposition of organic nitrogenous compounds be taken to signify that nitrogen is present in the added material in excess of the growth requirements of the organisms concerned, then the influence of the carbon/nitrogen ratio would, in fact, be expected to be more marked in the early stages of the transformation, when the supply of utilizable carbon compounds is greater, rather than at the end when nitrate values approach their maxima. Further experiments with amino-acids are in hand.

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Photoperiodic Induction in Jute and a Great Acceleration of Vegetative Growth in *C. capsularis*

Both the species of jute, *Corchorus capsularis* L. (*D* 154) and *C. olitorius* L. (*C.G.*), have been found to behave as short-day plants[1,2]. In a further investigation on the photoperiodic effect in jute, the effect of a number of light periods continuous until flowering and for shorter periods has been studied. The mean flowering time of twelve plants per treatment grown in pots and the mean heights at flowering were noted. There were two sowings—on April 17, 1948, and on June 2, 1948. Plants of April sowing were subjected to 14 days, 21 days and continuous 8 hours, and to 14 days, 21 days and continuous 10 hours treatments, and those of June sowing to 7 days, 14 days and continuous 10 hours and to 7 days, 14 days, 30 days, 60 days and continuous 14 hours treatments.

In *C. olitorius* the shortest flowering time is seen in 10 hours continuous treatments of April sowing, flowering in 21 days and showing an earliness of 105 days from control which flowered in 126 days, and there was no significant difference between the continuous 14 days and 21 days treatments for 8 hours periods, the mean flowering time being about 25 days. The heights at flowering in all the short-day treatments were also very low, varying between 6 cm. and 11 cm., except in 10 hours 14 days treatment the height of which at flowering was 28 cm. with a flowering time of 32 days. In the long light period treatments of June sowing, the greatest lateness of flowering of 98 days flowering in 185 days against 87 days of control and a greater height of 76 cm. (275 cm. against 199 cm. of control) are seen in 14 hours continuous treatment, but in 7 days, 14 days and 30 days treatments flowering takes place practically at the same time as control; but 60 days treatment causes a significant lateness, flowering in 91 days.

In *C. capsularis* the shortest flowering time of 33 days is found in 10 hours continuous treatment,

showing an earliness of 98 days from control which flowers in 131 days in the sowing of April, and a flowering time of 37 days is found in 10 hours continuous and 10 hours 14 days treatments of June sowing, showing an earliness of 56 days from control which flowers in 93 days. In the long light period treatments there is a lateness of flowering of 58 days in 14 hours continuous treatment which flowered in 151 days. Even 7 days treatment at 14 hours showed a significant lateness, and lateness increased with the duration of treatment (7 days, 14 days, 30 days and 60 days); but the difference in flowering time between 7 days and 14 days, 14 days and 30 days, and 30 days and 60 days treatments are not statistically significant, and the flowering time of 60 days treatment at 14 hours was 97 days.

C. capsularis seems to be slightly more sensitive to early period treatments in the long light periods than *C. olitorius*; but the latter is much more sensitive than the former to the early period treatments in short light periods. The photo-inductive cycle in the case of both the species consists of 10 hours light period and 14 hours darkness period, and for *C. olitorius* 14 cycles are sufficient to induce earliness of flowering, 21 cycles being necessary for the other species. In *C. capsularis* after exposure to 21 cycles it was found that although a few flowers were produced early, they were shed, and the plants after further prolonged vegetative growth came to the production of normal flowers leading to the production of fruits about the same time as the plants exposed to the normal daily light period. It may be said that in this case the amount of supposed flowering hormone produced had just reached the critical concentration, and the internal conditions of the plants so treated is similar to the plants of *C. olitorius* sown on March 31[2]; the works of Harder[4] on *Kalanchoe blossfeldiana*, and Meyer[5] on *Sedum*, to study the effect of reduced flowering hormone may be mentioned in this connexion.

In *C. capsularis* of March sowing in the 8 hours treatment for 14 days and 21 days and 10 hours treatment for 14 days, flowering took place only a few days earlier (by 8–13 days) than the control; but the differences are statistically significant. But these plants showed a remarkable acceleration of vegetative growth in that they grew to much greater heights (236 cm., 253 cm., 253 cm., respectively, against 182 cm. of the control), showing increased growth by 54–71 cm. That they showed an earliness of flowering points to the early production of flowering hormone during the short light period treatment, and that the flowering took place only a few days before the normal point, indicate that the auxin of vegetative growth was predominant, and the comparatively small concentration of the flowering hormone formed, below the critical concentration, could not express itself earlier; on the approach of the short light period of Nature, the balance between the flowering hormone and auxin shifted to the flowering side. Photoperiodic experiments with various plants point to the general conclusion that auxin exerts an influence which opposes flowering, and early production of flowers is associated with the inhibition of vegetative growth[6]; and Cholodny's thesis that the flowering stimulus is exerted by a group of substances, one of which is auxin, is not supported by the results of various experiments, although a striking exception of generally somewhat antagonistic effect of auxin to flowering is furnished by pineapple[7].

The acceleration of growth reported here is remarkable, and it may be that when the plants are exposed to non-photo-inductive cycles after the production of some concentration of flowering hormone less than the critical concentration by exposure to a few photo-inductive cycles, the flowering hormone is partly converted into, or more probably stimulates the production of larger quantities of, normal auxin of plant growth, and under such conditions the two factors do not seem to be working in opposite directions. Production of sufficient quantities of flowering hormone by exposure to large numbers of photo-inductive cycles more than the critical, however, produces great earliness of flowering accompanied by the usual inhibition of vegetative growth.

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Habits of the Marine Tardigrade, *Echiniscoides sigismundi*

It would appear that, although tardigrades are often common in many situations in fresh waters, they are comparatively rare, or at least have escaped frequent observation, in the sea. This is particularly true of British waters, for which only two records can be traced. Both of them refer to the same species, *Echiniscoides sigismundi* (Schultze). The first record is that of Murray[1] from the west coast of Ireland, and the second is that of Cole[2] in 1934 from North Wales. In both instances the creature was found among seaweeds. Yet it is quite clear both from Marcus[3] and Cuénot[4] that *E. sigismundi* is widely distributed in the Mediterranean, North Sea and Caribbean Sea, and even off the coasts of China. It is difficult to account for its apparent absence from most British coasts except on the supposition that it has not so far attracted attention.

In January of this year, three specimens were found in the mantle cavity of a common mussel brought from Whitstable by G. E. Newell, and on several subsequent occasions they have been found in similar situations. Yet, despite a careful search of seaweeds and of material sieved in a plankton net from the same area from which the mussels were obtained, no tardigrades have been found free-living. This leads to the view that some relationship other than a casual one exists between the tardigrades and the mussels. On the other hand, records from abroad give the creature as living with seaweeds, particularly the green alga *Enteromorpha*, so that, if any definite association with mussels does occur, then it is a facultative one. In support of this view it may be remarked that Marcus mentions several other marine tardigrades (not British ones) which seem to be associated with particular animals. One, for example, *Halechiniscus guiteli* Richters, is found in and on oyster shells. Another, *Actinarctus doryphorus* E. Schulz, Marcus

regards as a facultative parasite on the echinoid, *Echinocyamus pusillus*, and a third, *Tetrakentron synaptæ* Cuénot, is a parasite on the tentacles of the holothurian *Leptosynapta galliennei*.

Thus it is not unusual for a tardigrade to be associated with another invertebrate animal, and it may be suggested that *E. sigismundi* is a facultative commensal of the common mussel.

It may be useful here to point out that *E. sigismundi*, the only marine tardigrade so far to be reported as a member of the British intertidal fauna, is easily recognizable by being about 0·2 mm. long and having five to eleven claws (usually eight) on each of its four pairs of legs.

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March 3.

[1] Murray, J., *Proc. Irish Acad.*, **31**, No. 37, 2 (1911).
[2] Cole, H. A. (private communication to G. E. Newell, 1950).
[3] Marcus, E., "Das Tierreich", ed. Bronn, Lief. 66 (Berlin, 1936).
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Odour Trails of *Acanthomyops fuliginosus*

Since Bethe's[1] original work on the polarization of the scent trails of the ant *Acanthomyops niger*, numerous theories have been put forward to explain the phenomenon. The majority, particularly those of Wasmann[2], Forel[3] and Brun[4], resulted from work on *Acanthomyops fuliginosus*, a species which in Nature, unlike *A. niger*, forms long columns of workers going to and fro between nest and food. Polarization in these trails was claimed to arise from the individual pieces of the trail. According to Wasmann[2], these were the footprints of the workers, which would have a direction implicit in them, like a human footprint.

In a comparative study of the orientation capabilities of both *A. niger* and *A. fuliginosus*, the existence and shape of the scent trail has been demonstrated in the latter. The workers used were carrying larvæ into the nest from a pile placed in the centre of a circular glass arena, 1 ft. across. Very quickly a worker will learn the way to and from the larvæ and soon settles down to follow roughly the same course in the two directions. If the glass over which it is running is dusted with lycopodium powder, this adheres to the scent trail and throws it into relief.

Part of an odour trail of *Acanthomyops fuliginosus* (dusted with lycopodium powder). The arrows show the direction of running

The result can be photographed, showing a trail split up into dashes of about 4 mm. long, shaped so that they have the appearance of a drop of fluid extruded and drawn out in the direction of running, as will be seen on the accompanying photograph. It can also be seen without 'development' if the glass is held at an angle to the light. The form of the track varies with the individual and sometimes the dashes may be up to 8 cm. long. It is of interest that Brun[4] considered that scent trail-laying only took place when the workers were carrying food.

The ability to lay such a trail is under the control of the ant. In the first journeys over the cleaned glass, pieces of trail are laid while returning to the nest and the remainder of the distance covered by random movement. As familiarity increases, the trails are completed and new whole ones laid down, mainly while carrying the larvæ. The result after about ten journeys is a tangle of trails over the most favoured route. This confusion would clearly preclude any polarization based on the shape of the dashes, a criticism of Bethe's theory[1] which Wasmann put forward. Certainly a worker on its journey to the larvæ may, in the preliminary random search for the beginning of the trail, strike the trail midway and turn nestwards instead of towards the larvæ. Further, the trail is not followed in all its minute detail; but the ant runs with one antenna palpitating along the track. There is no sign of the antennæ being used as callipers to sense the 'odour form' of the trail, as Forel[3] postulated. This agrees with Chauvin's[5] findings of non-polarization of the trail in this ant and with his explanation that Bethe's results[1] of confusion, when sections of the trail are reversed, were due to the interruption of the trail rather than its inversion, since after the reversal the ends of the sections no longer coincided with the ends of the other parts of the trail. However, Macgregor[6] has supposed the spots forming the odour trail in *Myrmica ruginodis* to be orientated, since they appear to be interpreted by the individual in this way. The chemical constitution of the trail is under investigation. It seems likely that it is an anal secretion.

Despite Bethe's results[1], no similar trail has been demonstrated in *A. niger*. Indeed, from its behaviour under normal and experimental conditions, it is clear that this ant depends upon visual means of orientation. However, on one occasion when a worker was apparently disorientated, it showed the usual excitement behaviour by backing slowly in a close circle, jerking up and down with its abdomen vibrating, and at the same time a small amount of material was deposited. This, coupled with the stages of the journey during which the trail is laid by *A. fuliginosus*, suggests the possibility that the deposition of the scent trail may depend on excitation of the ant by the presence of food or larvæ and, from a by-product of heightened excitation *A. niger*, it has become the main method of orientation in *A. fuliginosus*.

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[2] Wasmann, E., *Zoologica*, **11**, 26 (1899).
[3] Forel, A., *Rec. Zool. Suisse*, 2-4 (1886).
[4] Brun, R., "Die Raumorientierung der Ameisen" (Jena, 1914).
[5] Chauvin, R., L'Année Psychologique. Mémoires Originaux "Sur l'expérience de Bethe" (1944–45).
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Feeding Mechanisms in Anuran Tadpoles

I CAN confirm that the method of mucous cord feeding referred to by Dodd[1] plays a part in the natural lives of tadpoles of *Rana temporaria*, *Bufo bufo* and *Bombina variegata* living under natural or semi-natural conditions. It is, however, remarkable that among the many tadpoles which have been examined, definite mucous cords have been seen in only a few. The animals appear to use this method when in the presence of fine particles; but seem to have another means of dealing with the coarse material which so often forms their food. Whole *Daphnia*, insect larvæ or spiders are not uncommon constituents of the food, and much exceed the diameter of the cords.

A study of the pharynx of several species of Anura has shown that the velum is in two parts, ventral and dorsal, of very different structure. The ventral velum is continuous with the floor of the pharynx, and appears to vary in elevation so that the water stream passing over it is sometimes directed at the posterior wall of the pharynx (in the centre, directly at the œsophageal opening); but in other positions of the ventral velum the water strikes the roof of the pharynx just anterior to the dorsal velum. This is a loose pocket, with the opening facing forward, and can be blown into shape by a stream of water. The relative positions of the edges of the dorsal and ventral vela are often such that the water must blow the dorsal velum open. It is in the shielded space on the downstream side of the dorsal velum that the mucous cords form; but the coarse material seems to collect more ventrally, when, indeed, it is not in the œsophageal funnel itself.

Water striking the posterior wall of the pharynx, or the œsophageal opening, must turn ventrally and then forwards through almost 180° before escaping through the gill filters. It is suggested that, during this sharp turn, large objects leave the stream due to centrifugal action. The efficiency of such separation increases with the size of the particles, so that the difficulty in the relative size of the cords and the food does not arise.

In a microphagous species, *Chaperina fusca*, the ventral velum is widely interrupted in the centre, just where in *Rana* and *Bufo* it is most strongly developed opposite the œsophagus; but the dorsal velum, which in *Rana* and *Bufo* is interrupted in the centre, is continuous in *C. fusca*, with merely a diminution in size near the central line.

The gill filters do not usually have much food upon them, and may serve merely to retain food not thrown out of the stream on the first circuit. It has always been difficult to explain how the food on the filters gets to the œsophagus against the prevailing current of water. If, however, the filters take a subsidiary role, this small amount of food may be thrown back into the pharynx by a back-wash of water from the atrium, during inspiration. The alternate passage of water containing, on both sides of the filter, suspended matter which is often gelatinous would seem to be a dangerous proceeding; but the atrium contains water which has already been filtered, and will not clog the filter on the under side.

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[1] Dodd, J. M., *Nature*, **165**, 283 (1950).

Exoerythrocytic Schizogony in Bat Malaria

MALARIA parasites of the epauletted fruit bats of tropical Africa have been described by Rodhain from the Belgian Congo, by Rousselot from French West Africa, and by myself from Kenya. Dr. R. B. Heisch, of the Division of Insect-borne Diseases, Kenya, noted the presence of a similar parasite in *Epomophorus wahlbergi* and was kind enough to have a number of these bats collected from near Nairobi for me when I was on a visit to the East African territories.

Seventeen bats were examined, and gametocytes were found in the blood of four. Tissues from the infected specimens were prepared for sectioning; in the liver of the most heavily infected were found the exoerythrocytic schizonts of the parasite. The smallest schizont was a spherical object about 45 μ in diameter with a deeply convoluted surface, and extremely dense cytoplasm studded with nuclei. A larger form measured 70 μ × 55 μ. These immature parasites lay between the parenchyma cells, and it was impossible to determine where they had originated. After a period of further growth, the substance of the parasite appeared to divide into a large number of well-defined cytomeres enclosed within a thick wavy border of unknown origin. These cytomeres were more numerous at the periphery, where presumably final division occurs. The last stage of merocyst formation was not found, though post-mature bodies were common in the shape of foci of phagocytic cells, including giant cells surrounding and invading many free merozoites. Such foci were easily visible as tiny white opaque spots on the surface of the liver.

Sections of heart and lung revealed no schizonts. Further examination of the material will be made at a later date.

Exoerythrocytic schizogony in insectivorous bat malaria was described by Mer and Goldblum[1], and has a totally different character from the appearances briefly recorded here. The latter are sufficiently striking to enable me to assign this parasite of African fruit bats to the genus *Hepatocystis*, the main features resembling the developmental stages of *H. kochi*.

I have pleasure in acknowledging the many facilities for this study provided by the Division of Insect-borne Diseases, Medical Research Laboratory, Kenya.

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[1] Mer, G. G., and Goldblum, N., *Nature*, **159**, 444 (1947).

Failure of Antibiotics in Experimental Rabies

As chloromycetin has shown promising results in various virus infections in man, it was decided to investigate its activity against experimentally induced rabies. Two rabbits were inoculated intracerebrally with the strain of fixed virus previously described by Kirk in *Nature*[1]. The rabbits received respectively 100 and 200 mgm. of chloromycetin per kilo daily, given in three equally divided doses by mouth. As controls three rabbits were used; two received 20,000 units penicillin in procaine oil per kilo daily, and the third 40 mgm. of streptomycin per kilo daily in two equally divided doses by intra-muscular

injection. Therapy was started in all cases twenty-four hours before inoculation. All five rabbits died on the fifth day and no change in the incubation period or manner of death could be detected.

It would appear that the antibiotics used have no effects on the progress of experimentally induced rabies.

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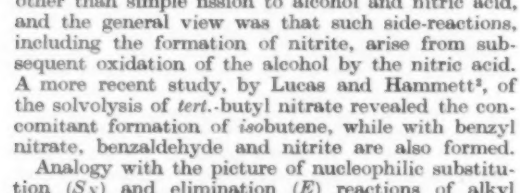
[1] *Nature*, **143**, 77 (1939).

Hydrolysis of Organic Nitrates

EARLY work[1] gives a very confused picture of the reactions which occur in either alkaline or acid hydrolysis of organic esters of nitric acid. The only clearly established point is the occurrence of reactions other than simple fission to alcohol and nitric acid, and the general view was that such side-reactions, including the formation of nitrite, arise from subsequent oxidation of the alcohol by the nitric acid. A more recent study, by Lucas and Hammett[2], of the solvolysis of *tert.*-butyl nitrate revealed the concomitant formation of *iso*butene, while with benzyl nitrate, benzaldehyde and nitrite are also formed.

Analogy with the picture of nucleophilic substitution (S_N) and elimination (E) reactions of alkyl halides, etc., which has resulted from the extensive investigations of Hughes, Ingold and their collaborators[3], and in which a duality of mechanism (uni- and bi-molecular) has been established, suggests that hydrolytic fission of organic nitrates might involve the following three reactions; for simplicity only the bimolecular mechanisms are depicted, although it is evident that, under suitable structural and environmental conditions, the corresponding unimolecular mechanisms may function:


R . CH2
X CH2—O . NO2 →
R . CH2 . CH2 . X + NO3′ (SN2) (alcohol + nitrate)
X H—CHR—CH2—O . NO2 →
CHR : CH2 + HX + NO3′ (E2) (olefine + nitrate)
R . CH2
X H—CH—O—NO2 →
R . CH2 . CH : O + HX + NO3′ (Ec2) (carbonyl + nitrite)

These involve, respectively, attack by the nucleophilic reagent $X(= OH', H_2O, ROH$, etc.) at the α-carbon, β-hydrogen or α-hydrogen. Theoretically, all these reactions might occur in either alkaline, neutral or acid media.

We are engaged on a detailed kinetic study of these reactions for a large number of organic mono-nitrates in dilute alkaline, neutral and acid aqueous alcoholic solutions, in which the separate reactions I–III have been followed by parallel determinations of OH' (or $H_2\overset{+}{O}$), NO_3', NO_2', olefine, and carbonyl derivative. One inherent difficulty in determinations by acid–alkali titration is the very small velocity of hydrolysis of simple alkyl nitrates in dilute solution, with the result that, in alkaline media, extensive alkali attack on glass vessels occurs during the course of the experiments, so that the values of $[OH']$ obtained bear no relation to the true course of the nitrate hydrolysis. This is a factor which would seem to have been overlooked in the early investigations. This difficulty has been overcome by designing suitable polythene vessels, for which it has been shown that any alkali attack on the vessel is negligibly small during the (prolonged) period over which the hydrolytic reactions have been studied. Under these conditions there is satisfactory agreement between the loss of $[OH']$ and the amount of nitrate formed (when only reactions I and II occur), or of nitrate plus nitrite (when all three reactions are superimposed).

Although our data are as yet incomplete, sufficient have been obtained to prove a corresponding agreement between the amount of NO_3' and C=O derivative formed (reaction III) throughout the course of the reaction. As expected, under the experimental conditions, no oxidation of alcohol is effected by the nitrate ion.

It would appear, therefore, that the formation of olefines, carbonyl derivatives and nitrite does not arise from secondary reactions but from the concomitant occurrence of three main reactions, in two of which (I and II) fission occurs at the C—O linking, and in the third (III) at the O—N linking in the nitrate molecule.

A fuller account of this work will be published elsewhere when the investigation is complete.

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[1] Cf., *inter alia*, Farmer, *J. Chem. Soc.*, **117**, 806 (1920); and references cited there.
[2] *J. Amer. Chem. Soc.*, **64**, 1928 (1942).
[3] For summarizing papers, cf. Hughes, *Trans. Farad. Soc.*, **37**, 603 (1941); Hughes and Ingold, *ibid.*, 657.

Role of Oxygen in the Photolysis of Iodides

THE decomposition by ultra-violet light of organic compounds containing iodine in solution has been the subject of many investigations, and references to this phenomenon are scattered throughout the photochemical literature. Summaries of the results and conclusions reached by the various investigators have been fairly well dealt with in recent books on the subject[1]. In the majority of cases, the quantum yields of the photochemical process have been determined by the amount of iodine formed in relation to the light absorbed. For the alkyl iodides, at least, these yields show no intelligible variation among themselves, and often the yield for a particular iodide varies from one investigator to another. There always has been a doubt as to whether or not dissolved oxygen was involved in the photolysis[2], in spite of the fact that many investigators have taken the trouble to distil their materials *in vacuo*, or to bubble inert gases through the solution before the photolysis. More convincing work along these lines has been undertaken in recent years by Olaerts and Jungers[3]; but it remains to be seen if they have really succeeded in removing the last trace of oxygen from their solutions.

During an investigation of the photodecomposition of iodoacetic acid in hexane, we noticed that the quantum yield for iodine formed (Φ_{I_2}) continued to decrease as more and more precautions were taken to remove the last traces of dissolved oxygen. When no trouble was taken to remove atmospheric oxygen,

$\Phi_{I_2} = 0{\cdot}49$; after bubbling pure, oxygen-free nitrogen through the solution, $\Phi_{I_2} = 0{\cdot}42$; on distilling and freezing out *in vacuo*, $\Phi_{I_2} = 0{\cdot}38$. A more extensive distillation *in vacuo* was then undertaken: the solution was transferred by evaporation and condensation from one vessel to another at least six times. It was then found that although the amount of light absorbed was the same as before for the same concentration, the yield of iodine was practically negligible, $\Phi_{I_2} = 0$. As soon as the solution was opened to the air and oxygen allowed to dissolve, iodine began to form at the same rate as before.

We repeated the photolyses in hexane of such iodides as methyl, ethyl, *iso*-amyl, iodobenzene and *p*-iodotoluene in the presence of oxygen, where we found $\Phi_{I_2} \sim 0{\cdot}5$, and after extensive removal of oxygen, $\Phi_{I_2} < 0{\cdot}05$. If we accept the evidence derived from a study of the absorption spectra of such compounds that rupture of the C—I bond follows on the light absorption, we can only assume that negligible quantum yields are due to recombination of the radicals, R, with the iodine atoms. Does this recombination take place by the formerly accepted mechanism of Franck–Rabinowitsch[4]? If the dissolved oxygen reacts with the radical according to accepted ideas[5], the radical and the iodine atom must remain uncombined and surrounded by a sheath of solvent molecules for a relatively long time to enable such reactions to take place. One of us (T. I.) pointed this out some years ago[6] in a criticism of Bamford and Norrish's interpretation of ketone photolysis in hexane solution[7].

If the recombination does not take place by a Franck–Rabinowitsch mechanism, we must assume that the reaction $R + R = RR$ is a very rare one compared with the reaction $R + I = RI$. When the oxygen concentration is sufficiently high, the reaction $R + O_2 = RO_2$, etc., becomes of importance. Oxygen has a fairly high solubility in hydrocarbons[8], and its removal is evidently not easy. These considerations apply, *mutatis mutandis*, to the photolysis in solution of other kinds of substances involving radicals susceptible to oxidation. It does not necessarily follow that gaseous products will be formed, and that evidence of photochemical change will be discovered by micro-analysis of evolved gases. Minute amounts of oxidized and condensation products would have to be looked for. Iodine betrays its presence, even in small amounts, by its colour, and its analytical determination is relatively easy. That is why this phenomenon has been so readily detected in the case of the iodides. At higher temperatures the solubility of oxygen is less, and we find increasing reactivity of the radical with the hydrocarbon solvent, where the activation energy must be higher than that required for the oxidation. More experimental details and theoretical treatment of the results of these investigations will be published soon.

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[1] For example, Rollefson and Burton, "Photochemistry" (1942).
[2] Dickinson, *Chem. Rev.*, **17**, 416 (1935).
[3] Discuss. Farad. Soc., No. 2, 228 (1947).
[4] *Trans. Farad. Soc.*, **30**, 120 (1934).
[5] Bladel, Ogg and Leighton, *J. Amer. Chem. Soc.*, **64**, 2499 (1942).
[6] *Nature*, **150**, 579 (1942).
[7] *J. Chem. Soc.*, 1531, 1544 (1938).
[8] Gniewasz and Walfisz, *Z. phys. Chem.*, **1**, 70 (1887).

Monoclinic Thorium Silicate

The name 'huttonite' is proposed for a newly recognized monoclinic mineral of the composition $ThSiO_4$. It has been isolated in minute grains from beach sand of South Westland, New Zealand, by Prof. C. Osborne Hutton, of Stanford University. Its optical properties are: $\alpha = 1{\cdot}898$, $\beta = 1{\cdot}900$, $\gamma = 1{\cdot}922$; dispersion $\rho < \gamma$, moderate; $2V = 25°$ (measured); $Y \parallel b$, Z near c; colourless to very pale cream. X-ray study by means of powder, rotation and Weissenberg patterns shows that huttonite is isostructural with monazite. Space group $C2_h^5 - P2_1/n$; $a_0 = 6{\cdot}80$ A., $b_0 = 6{\cdot}96$ A., $c_0 = 5{\cdot}54$ A., $\beta = 104° 55'$. The measured density is $7{\cdot}1 \pm 0{\cdot}1$. The calculated density, corresponding to a cell content of $4(ThSiO_4)$, is 7·18.

A full description has been submitted to the *American Mineralogist*.

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The Sulphatase of 'Clarase': Inhibition, Inactivation and Purification

The optimal conditions and specificity of the enzyme sulphatase of 'clarase' have been described in a previous communication[1]. The method then used of measuring the activity of the enzyme by the gravimetric estimation of sulphate liberated from the substrate has now been abandoned, and a new colorimetric method adopted. In this the amount of phenol set free from the substrate (potassium phenylsulphate) in the course of enzymic hydrolysis is determined, as was done by King and Armstrong[2] for the determination of phosphatase.

Inhibition. The influence of various substances known to be enzyme inhibitors has been examined, as well as that of other compounds not necessarily regarded as such. Of all the substances tested, phenylhydrazine proved to be the most powerful inhibitor of the sulphatase of 'clarase'. Even at a concentration of 10^{-6} M, phenylhydrazine produces a 25 per cent inhibition, and when its concentration is raised to 10^{-5} M, the sulphatase activity ceases completely. Other inhibitors of the sulphatase, in order of decreasing inhibitory action, are named in the accompanying table.

Action of Inhibitors on Sulphatase of 'Clarase'

Inhibitor	Molar concentration	% Inhibition
Sodium cyanide	10^{-4}	100
Silver nitrate	10^{-3}	100
Semicarbazide	10^{-3}	77
Lead acetate	10^{-3}	44
Potassium hydrogen phosphate	10^{-1}	25

Other substances, such as barium chloride, ethyl alcohol and strontium nitrate, had no inhibitory effect even at a concentration of 10^{-2} M.

Inactivation. Sulphatase of 'clarase' is very sensitive to low *p*H. At *p*H 3 it is irreversibly inactivated after ten minutes, and after five minutes an 80 per cent inactivation of the enzyme occurs.

Purification. A partial purification of the sulphatase of 'clarase' has been achieved by means of fractional precipitation with ammonium sulphate

At 50 per cent saturation with ammonium sulphate, an inactive fraction of 'clarase' is precipitated. In this way, a more concentrated preparation may be obtained. Further attempts are being made towards complete isolation of the enzyme.

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March 26.

[1] Działoszynski, L. M., *Nature*, **160**, 464 (1947).
[2] King, E. J., and Armstrong, A. R., *Canad. Med. Assoc. J.*, 376 (Oct. 1934).

Reciprocal Detoxifying Effects of 'Benadryl' and 'Aminopterin'

An attempt has been made to overcome the toxic effect of the 4-aminopteroylglutamic acid, the new powerful folic acid antagonist[1]. Aminopterin is toxic to all laboratory animals used and also to human beings[2–7]. Its toxic effects are difficult to prevent or to reverse by administration of folic acid[8–10], whereas the effects of the *X*-methyl analogues of folic acid are easily reversed by administration of folic acid[8]. In the experiments reported here, 'Benadryl' was used in an attempt to antagonize the toxic effects of 'Aminopterin'.

Twenty albino mice (mean weight, 25 gm.) were divided in two series, as follows:

	First series	Second series
No. of mice treated	10	10
Single injection of 'Aminopterin' intraperitoneally	1 mgm.	1 mgm.
'Benadryl' subcutaneously	None	0·5 mgm. twice daily
Mortality	10/10	10/10
Death following the injection of 'Aminopterin'	0–1 day	2–4 days
	2–2 days	4–5 "
	4–3 "	4–6 "
	4–4 "	

These results, although limited, suggest that 'Benadryl' is able to a moderate extent to delay death in mice treated with a single injection of 1 mgm. of 'Aminopterin' intraperitoneally. To determine whether a true relationship might be present between the two substances, experiments were performed to determine the effects of 'Aminopterin' on guinea pigs treated with a lethal dose of 'Benadryl'. The lethal dose of 'Benadryl' varies with the animals used[11,12]. In guinea pigs, the intraperitoneal injection of 40 mgm. per kgm. was often followed by a convulsive state which ended with the death of the animals[12].

Of twenty guinea pigs (mean weight, 625 gm.), ten, used as controls, were given 25 mgm. of 'Benadryl' intraperitoneally. Within ten minutes all the animals went into a convulsive state that lasted about three hours, after which four of them died. The other ten guinea pigs were given 1 mgm. of 'Aminopterin' intraperitoneally, and, ten minutes later, 25 mgm. of 'Benadryl' was given by intraperitoneal injection. None showed convulsions, and all the animals survived. Similar experiments were repeated with twelve guinea pigs (mean weight, 625 gm.) in which a larger dose of 'Benadryl' was used. Six were given 50 mgm. of 'Benadryl' intraperitoneally and all the animals died following severe convulsions. In the other six guinea pigs, 1 mgm. of 'Aminopterin' intraperitoneally was given, and ten minutes later 50 mgm. of 'Benadryl' was injected by the intraperitoneal route. All the animals developed convulsions and only two recovered.

These experiments indicate that 'Aminopterin' is able to prevent the guinea pigs from going into a convulsive state and from death when a dose of 40 mgm. per kgm. of 'Benadryl' is used. Using larger doses of 'Benadryl', the protective action of the 'Aminopterin' is decreased or lost.

V. Traina

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Feb. 27.

[1] Seeger, D. R., Smith, J. M., jun., and Hultquist, M. E., *J. Amer. Chem. Soc.*, **69**, 2567 (1947).
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[3] Minnich, V., and Moore, C. V., *Fed. Proc.*, **7**, 276 (1948).
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[5] Farber, S., Diamond, L. K., Mercer, R. D., Sylvester, R. F., and Wolff, J. A., *New England J. Med.*, **238**, 787 (1948).
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[8] Higgins, Geo. M., *Blood*, **4**, 1142 (1949).
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[11] Gruhzit, O. M., Fisken, R. A., *J. Pharm. and Exp. Ther.*, **89**, 227 (1947).
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[13] Gruhzit, O. M. (personal communication).

South African Fossil Hominoids

Prof. Le Gros Clark[1] seems to have misunderstood the point of my communication[2] about the South African fossil anthropoids. I have nowhere claimed that "the major dimensions and indices of individual teeth can by themselves provide adequate information on which to base statements regarding affinities of primitive hominids and anthropoid apes". The object of my note was to show that adequate comparisons by proper statistical procedures fail to substantiate a commonly stated view that the teeth of the South African Australopithecine apes differ significantly in size and general shape from those of existing apes. Whatever its other purpose, his letter may, however, help to underline the object of my communication and of the studies on which it was based.

Both in his letter and in an earlier communication[3], Prof. Le Gros Clark states that he bases his conclusions on a comprehensive view "of the total morphological pattern", and that he does not rely on "a few metrical features considered as isolated abstractions". Whatever he may mean by "total morphological pattern"—and its meaning cannot be very much different from the term "constellation of characters" or "character complex" more commonly used in taxonomy—it is compounded of an arbitrary and variable number of different items, and is no less an abstraction than the dimensions of individual teeth. Furthermore, it comprises both metrical and "qualitative" features. For example, Prof. Le Gros Clark refers to "the small size (relative and absolute) and the spatulate form" of the (permanent) canine; the "small (permanent) incisors" and "the shape and dimensions (relative and absolute) of the milk canine". Most of these attributes can easily be given proper numerical definition. Some others referred to by Prof. Le Gros Clark do not lend themselves so readily to quantitative statement.

Now, however many features the "total morphological pattern" may comprise, each is considered separately before it is compounded with the rest. It is a useful precaution, therefore, to be certain that the metrical attributes which are used in building up distinctive constellations of characters are accurately stated. Unfortunately, the three to which Prof. Le Gros Clark refers in his letter are not.

"Small" and "big" are qualitative words which acquire exact significance in relation to some given standard. Prof. Le Gros Clark does not tell us what the standard is; but he is, in fact, repeating the observations of Broom, Dart and others who have written about the teeth of the Australopithecinæ, and all of whom have emphasized the view that the teeth to which he refers are smaller than the corresponding one of existing anthropoid apes. In fact, proper numerical comparisons show this view to be incorrect, in so far as the extent to which the recorded dimensions and indices of the fossil teeth in question diverge from the means of one or other existing species of anthropoid ape is in most cases no greater than the extent to which, say, one chimpanzee in twenty will on an average diverge from the mean of its species, and in no case greater than the extent to which one great ape in fifty would diverge from its species-mean.

The most extensive set of data about the size of the teeth of the Australopithecinæ are given in the 1946 monograph published by Dr. R. Broom[4], and in a second monograph on *Plesianthropus* which has just appeared[5]. The claim (e.g., Senyurek[6]) that the upper lateral permanent incisor of *Plesianthropus* is smaller than that of the living anthropoids and that in the extent of its reduction it parallels later stages of human evolution is not borne out by adequate comparisons. The tooth is not significantly smaller than that of the modern female gorilla, and very little, if at all, smaller than that of the female orang-utan. The lower first permanent incisor of *Plesianthropus*, again, does not deviate in size from the female chimpanzee, the female gorilla, or the male or female orang-utan. The lower second incisor does not differ significantly from that of either sex of gorilla, or from the male orang.

The claims that have been made by Gregory and Hellman[7], Broom[4,5] and Senyurek[6] about the small size of the upper and lower canines of the Australopithecinæ are again not borne out by proper comparisons, for neither the upper nor the lower permanent canine diverges significantly in its proportions from that of the adult chimpanzee.

Lastly, contrary to Prof. Le Gros Clark's belief, the milk canines of *Australopithecus africanus* and *Paranthropus robustus* do not differ "in shape and dimensions, relative and absolute" from the chimpanzee, while that of *Paranthropus crassidens* does not deviate from the orang.

In so far, therefore, as these metrical attributes are not as Prof. Le Gros Clark describes them, the "total morphological pattern" is not as one would infer it to be from his account.

These matters of fact, which are fully elaborated elsewhere[8] (and not broad questions of primate phylogeny, about which, to the best of my knowledge, Prof. Le Gros Clark and I share the same views), were the reason behind the communication on which Prof. Le Gros Clark commented. His letter thus directs further attention to the essential need for a biometric and statistical approach to the comparative study of Primates, unless, of course, there is some other line of attack which can replace exact methods of osteological and odontological study.

S. Zuckerman

Department of Anatomy,
Medical School, Hospitals Centre,
Birmingham 15. June 24.

[1] Clark, W. E. Le Gros, *Nature*, **165**, 893 (1950).
[2] Zuckerman, S., *Nature*, **165**, 652 (1950).
[3] Clark, W. E. Le Gros., *Quart. J. Geol. Soc. Lond.*, **105**, 225 (1950).
[4] Broom, R., and Schepers, G. W. H., *Transv. Mus. Mem.*, No. 2 (1946).
[5] Broom, R., Robinson, J. T., and Schepers, G. W. H., *Transv. Mus. Mem.*, No. 4 (1950).
[6] Senyurek, M. S., *Ann. Transv. Mus.*, **20**, 293 (1941).
[7] Gregory, W. K., and Hellman, M., *Ann. Transv. Mus.*, **19**, 339 (1939).
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A Joule Museum at Manchester

The support of the University of Manchester and the British Society for the History of Science has been secured for the arrangement of a small museum to commemorate the work of James Prescott Joule, the discoverer of the Law of Conservation of Energy. Besides showing various original instruments and documents which belonged to Joule, it is planned to display reconstructions of the main apparatus used by him in his investigations, and other material illustrating the early history of the discovery.

I should like to appeal to any person or institution in possession of documents, letters or unpublished information concerning Joule, to get into touch with me. I am also interested in any material pertaining to the early relations between Joule and William Thomson (later Lord Kelvin).

L. Rosenfeld

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Manchester 13.

Phosphorus in Peripheral Nerve

In a letter published in *Nature*[1], certain observations were quoted on the longitudinal distribution of phosphorus in the sural nerve. Recalculation gives phosphorus contents which do not, in many cases, agree with the previous calculations.

The following are the re-calculated figures.

(1) In nerves stimulated *in vitro* at the distal end, the mean difference between the phosphorus content of the proximal and distal ends is 73 ± 33 μgm./100 mgm. (eleven nerves), and in four cases the distal phosphorus content is greater than the proximal.

(2) In nerves stimulated *in vitro* at the proximal end, the mean difference between the ends is 92 ± 49 μgm./100 mgm. (eight nerves), and in three cases the distal phosphorus content is greater than the proximal.

(3) In fourteen resting nerves the mean difference between proximal and distal ends according to the previously published figures is 4 ± 15 μgm./100 mgm. The recalculated figures show the difference as 6 ± 27 μgm./100 mgm.

As the differences in the stimulated and resting nerves are not significantly different, the conclusions drawn in the paper are not valid.

Gilbert Causey

Department of Anatomy,
University College,
London, W.C.1.

[1] Causey, G., and Werner, G., *Nature*, **165**, 762 (1950).

FORTHCOMING EVENTS

Tuesday, July 25—Friday, July 28

INSTITUTE OF PHYSICS, INDUSTRIAL RADIOLOGY GROUP (at the New Horticultural Hall, Victoria, London, S.W.1).—Summer Meeting.

Wednesday, July 26

BRITISH MYCOLOGICAL SOCIETY (in the Department of Botany, The University, Reading), at 11 a.m.—Scientific Papers.

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned :

AREA GAS EXAMINERS (male) in the Ministry of Fuel and Power—The Secretary, Civil Service Commission, Scientific Branch, 7th Floor, Trinidad House, Old Burlington Street, London, W.1, quoting No. 3145.TF (July 27).

HYDRO-ELECTRIC ENGINEER in the Chief Engineer's Department at London headquarters—The Secretary's Office (Establishments), Applications Section, British Electricity Authority, British Electricity House, Great Portland Street, London, W.1, quoting Ref. AE.74 (July 28).

STATISTICIAN in the Department of Agriculture, Oil Palm Research Station, Benin, Nigeria—The Director of Recruitment (Colonial Service), Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1 (July 28).

ASSISTANT LECTURER IN ZOOLOGY—The Secretary, The University, Birmingham 3 (July 29).

ASSISTANT LECTURERS (2) IN THE DEPARTMENT OF INORGANIC AND PHYSICAL CHEMISTRY—The Registrar, The University, Liverpool (July 29).

CHEMISTS (Scientific Officer and Experimental Officer grades, unestablished) at the Radiochemical Centre, Amersham, Bucks, for the development of new synthetic methods and the preparation of compounds containing the radioactive isotope Carbon-14—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting F.398/50A (July 29).

JUNIOR PHYSICIST to the Radiotherapy Services—The Secretary, Newcastle-upon-Tyne Regional Hospital Board, Dunira, Osborne Road, Newcastle-upon-Tyne 2 (July 29).

LECTURER IN THE ELECTRICAL ENGINEERING DEPARTMENT—The Clerk to the Governors, Woolwich Polytechnic, Woolwich, London, S.E.18 (July 29).

LECTURER IN RADIO COMMUNICATION—The Secretary, South-East London Technical College, Lewisham Way, London, S.E.4 (July 29).

PATENT EXAMINERS (with honours degree in physics, chemistry, electrical engineering or mechanical engineering, or an equivalent qualification) in the Board of Trade (Patent Office), the Admiralty, and in the Patent Officer class in the Ministry of Supply—The Secretary, Civil Service Commission, 6 Burlington Gardens, London, W.1, quoting No. 3170 (July 29).

MATHEMATICIANS (Scientific Officer grade, unestablished) in the Statistical Group of Ordnance Board in London—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting A.185/50A (July 31).

MECHANICAL or AERONAUTICAL ENGINEERS (Experimental Officer grade) at the Royal Aircraft Establishment (Structures Department), Farnborough, Hants, for operational research on aircraft flight load conditions (Ref. C.312/50A), and development of strain measuring technique (Ref. A.173/50A)—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting the appropriate Ref. No. (July 31).

METALLURGISTS (unestablished) at a Ministry of Supply Research Establishment in London : (Ref. F.408/50A) PHYSICAL METALLURGISTS (Scientific Officer grade) with first- or second-class honours degree in metallurgy and research experience in metallography ; (Ref. F.409/50A) EXPERIMENTAL OFFICER or ASSISTANT EXPERIMENTAL OFFICER (*a*) with an interest in research on refractories, (*b*) for analytical metallurgical work—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting the appropriate Ref. No. (July 31).

PHYSICAL CHEMISTS (Scientific Officer grade, unestablished) at Ministry of Supply Research and Development Establishments in and near London : SENIOR SCIENTIFIC OFFICER (in London) for work in the Industrial Explosives Section, and a SCIENTIFIC OFFICER (near London) with a good honours degree in chemistry, and postgraduate research experience desirable—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting F.399/50A (July 31).

PHYSICISTS (Experimental or Assistant Experimental Officer grade, unestablished) in a Ministry of Supply Research Establishment in London, for experimental work with radioactive materials including radiation measurements for health physics and instrument construction, calibration and maintenance—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting A.189/50A (July 31).

PHYSICISTS (Scientific Officer grade, unestablished) with good honours degree in physics and experience in applied physical research, at a Ministry of Supply Experimental Establishment in South-West England—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting A.183/50A (July 31).

PHYSICISTS (Scientific Officer grade, unestablished) at the Royal Aircraft Establishment, Farnborough, Hants, (*a*) for work on display, computor and communication research, (*b*) for work on V.H.F. and U.H.F. navigation, direction finding and landing systems—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting A.184/50A (July 31).

PHYSICISTS (Senior Scientific Officer or Scientific Officer grade, unestablished) at a Ministry of Supply Research Establishment in London, for the handling and measurement of radioactive materials—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting A.188/50A (July 31).

PHYSICISTS and ENGINEERS (Experimental Officer grade, unestablished) at the Royal Aircraft Establishment, Farnborough, Hants, for (*a*) development work on electrical and optical apparatus for measurement of flight parameters, (*b*) circuit design and engineering of miniaturized radar equipment, and (*c*) light mechanical and electrical design for work on small servo mechanisms, etc.—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting A.186/50A (July 31).

ENTOMOLOGIST in the Department of Agriculture and Lands, Southern Rhodesia—The Secretary to the High Commissioner for Southern Rhodesia, 429 Strand, London, W.C.2 (August 5).

PHYSICAL CHEMISTS (Experimental Officer grade, unestablished) with an interest in chemical plant development work, at a Ministry of Supply Research Establishment near London—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting F.406/50A (August 7).

SENIOR EXPERIMENTAL OFFICER (Ref. F/400/50A) for development of methods of ignition of rocket motors, and an EXPERIMENTAL OFFICER or ASSISTANT EXPERIMENTAL OFFICER (Ref. C.326/50A) for work on the development of solid propellant rocket motors, and (Ref. D.190/50A) for development, construction and installation of electronic equipment for test and for recording flight parameters, at an outstation of the Royal Aircraft Establishment in Bucks—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting the appropriate Ref. No. (August 7).

PROFESSOR OF PHYSICS, and a PROFESSOR OF BOTANY—The Registrar, University of Dacca (P.O. Ramna), East Bengal, Pakistan (August 31).

LECTURER IN BOTANY—The Secretary, Queen's University, Belfast (September 15).

ASSISTANT LECTURER (probationary) IN METALLURGY—The Registrar, University College, Singleton Park, Swansea.

BOTANIST for a Tsetse Fly Survey in Nyasaland, to carry out a study of the botanical side of ecology of tsetse fly in conjunction with the Tsetse Entomologist—The Under-Secretary of State, Colonial Office, Research Department, Sanctuary Buildings, Great Smith Street, London, S.W.1.

CHAIRMANSHIP OF THE DEPARTMENT OF BACTERIOLOGY in the Faculty of Medicine—Dean L. G. Bell, Faculty of Medicine, University of Manitoba, Winnipeg, Canada.

CHEMIST for work on mushroom composts and related subjects—The Director of Research, Mushroom Research Association, Yaxley, Peterborough.

INSPECTORS OF MINES, H.M. Colonial Service, Nigeria—The Director of Recruitment, Colonial Service, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting 27099/13.

LECTURER IN AIRCRAFT STRUCTURES—The Head of the Aeronautics Department, Imperial College of Science and Technology, South Kensington, London, S.W.7.

LECTURER IN CHEMISTRY—The Clerk to the Governors, Roya Technical College, Salford 5.

PHYSICAL CHEMIST (honours degree in physical chemistry, preferably in electrochemistry or corrosion, desirable) in the Electrochemistry Section of the Coatings Laboratory—The Personnel Officer, British Iron and Steel Research Association, 11 Park Lane, London, W.1.

PHYSICIST (with good honours degree in physics and at least one year's research experience)—The Director of Research, British Scientific Instrument Research Association, Sira, Southill, Elmstead Woods, Chislehurst, Kent.

RESEARCH PHYSICIST to work on the development of instruments for sampling airborne dusts, especially in coalmines, and on the physical properties of dust particles at rest and moving in an air stream—The Director, Pneumoconiosis Research Unit, Llandough Hospital, Cardiff.

RESEARCH WORKER to take charge under Head of Nutrition Department of work on the microbiological assay of vitamins and other factors—The Secretary, National Institute for Research in Dairying, Shinfield, Reading, Berks.

SENIOR FORECASTER (with University degree, preferably in Science and specialized in Meteorology) (Ref. M/N/26337/3E), and ASSISTANT FORECASTERS (with University degree, preferably in Science and specialized in Meteorology) (Ref. M/N/26338/3E), for the Basrah Port Directorate, Government of Iraq—The Crown Agents for the Colonies, 4 Millbank, London, S.W.1, quoting the appropriate Ref. No.

REPORTS and other PUBLICATIONS

(*not included in the monthly Books Supplement*)

Great Britain and Ireland

B.I.O.S. Surveys Report No. 22 : The Paint Industry in Germany during the Period 1939–1945. By Nell R. Fisk and H. W. Bowron. Pp. 153+4 plates. (London : H.M. Stationery Office, 1950.) 3*s.* net. [Corrected entry] [274

University of London : University College. Annual Report, March 1948–September 1949. Pp. 233. (London : University College, 1950.) [235

The Bowater Papers. No. 1. Pp. 64. (London : Bowater Paper Corporation, Ltd., 1950.) [255

Other Countries

Ceylon Coconut Quarterly. Vol. 1, No. 1, January–March. Pp. 40. (Lunuwila : Coconut Research Scheme, 1950.) 50 cents. [255

Administration Report of the Government Museum, Madras, Pudukkottai Museum, and the Connemara Public Library, Madras, for 1948–49. Pp. 36. (Madras : Government Press, 1949.) [255